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CHILD DEVELOPMENT

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NUTRITIONAL STATUS OF SCHOOL CHILDREN IN A SMALL INDUSTRIAL CITY[1]

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AND ARTHUR W. BAUMAN

As a part of a long-time study in human nutrition begun in 1935 by the Division of Home Economics Research at The Pennsylvania State College for the purpose of finding the dietary habits and the nutritional status of persons of different ages and socio-economic types, the study reported herein was carried on in December, 1936, and January, 1937.

SUBJECTS

The subjects of the study were children in a city of about 82,000 inhabitants, in which industrial activity, centered around extensive railroad shops, had been relatively limited for a number of years. The children, 428 in number, were selected from the 28 grade schools of the city in such a way as to give distribution with respect to the occupation and income of their respective parents comparable with that of the community as a whole. Three per cent of the children came from families with a cash income of $2500 and over; 47.4 per cent from $2499 to $1000; and 49.6 per cent below $1000. The distribution of the children with respect to the cash incomes of their families is shown in Figure 1.

METHODS OF PROCEDURE

Data concerning the socio-economic status of the children's families, as well as their diets were secured by visits to their homes by nurses assisting in the study. The two factors used in this report for representing the socio-economic status of the children were: (a) the cash income of the family; and (b) the education of the adults within the family.

Family Cash Income Groups. For convenience, five arbitrary cash income groups were used in classifying the incomes of the families, as follows:

Class A, $5000 annual cash income and above;
Class B, $4999 to $2500, inclusive;
Class C, $2499 to $1000, inclusive;
Class D, below $1000 but not on direct governmental relief; and
Class E, direct governmental relief.

Family Education Groups. Furthermore, five arbitrary educational groups were used in classifying the respective families of the children as to family education, as follows:

Class A, all adults college graduates with at least a bachelor's degree;

[1] *A joint contribution of The Pennsylvania State College and the Department of Health of the Commonwealth of Pennsylvania. Authorized February 23, 1940, as Paper Number 5 in the Human Nutrition Research Series of the Division of Home Economics Research, The Pennsylvania State College.*
The authors are indebted to Catherine Logan, Anne O'Brien and various technical helpers for valuable assistance in this study.

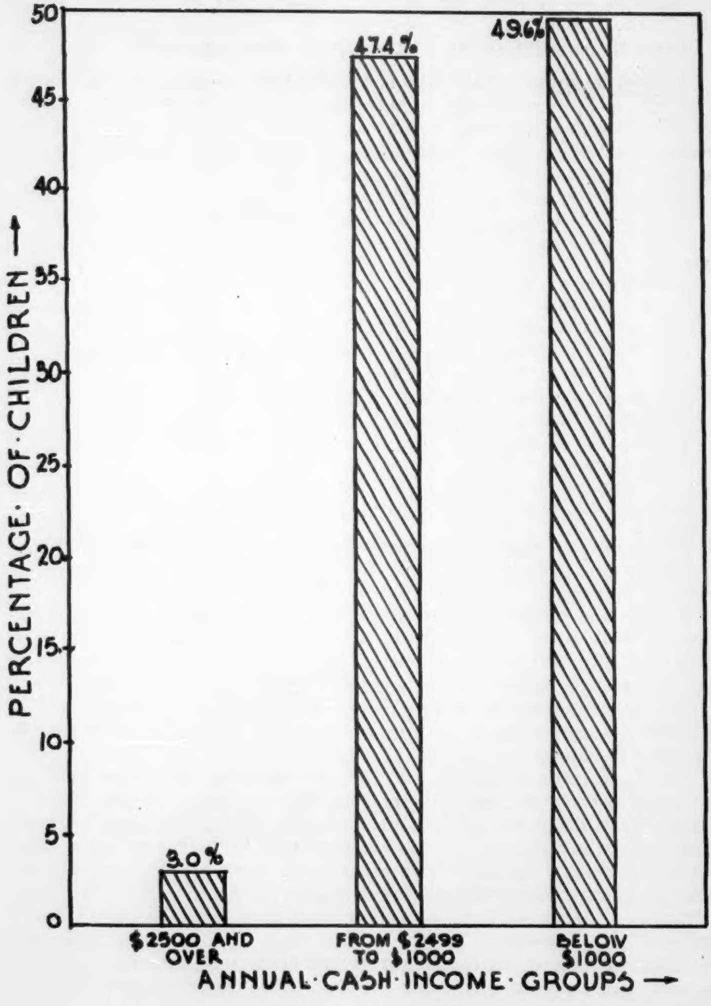

Fig. 1. Percentage Distribution of Children with Respect to Cash Income.

Class B, one adult a college graduate or a recipient of some special training beyond high school;
Class C, all adults high school graduates;
Class D, one or more, but not all adults in the family high school graduates;
Class E, no adult in the family a high school graduate.

Dietary Records. Funds were not sufficient to supervise the keeping of extensive dietary records in this study. A report of the food consumption of each child during a typical three-meal week-day was secured from the mother or other adult in the family by one of the visiting nurses. Independently, each child gave a report of his food intake during a typical three-meal day at two separate times.

Nutritional Measurements. The following nutritional measurements were made on each of the children in the study:

(a) Appearance of nutritional status by a physical examination rating;
(b) Body build and weight status;
(c) Skeletal status - maturation, areas of wrist centers, and degree of mineralization;
(d) Dental status;
(e) Slump, standing and sitting;
(f) Plantar contact;
(g) Hemoglobin status;
(h) Response to a biophotometer test;
(i) Response to a capillary wall strength test.

Details of the nutritional tests have been given by Mack and Smith (5), and consequently only a brief statement is made concerning each test:

A composite score was given to each child as a result of a physical examination in which an adjustable number of points was alloted for such factors as skin, pallor, subcutaneous tissue, musculature, posture, plantar contact, skeletal status, evidence of presence or absence of fatigue, condition of the mouth, luster of the hair, and nervous habits. The highest total score which could be made from this subjective examination was 100 points.

In ascertaining body build, 26 body measurements were taken with calibrated metal anthropometric instruments, from which 16 body build indices were calculated. The results of this part of the study will be reported at a later time. In the present paper, only the weight status of the children is discussed - as ascertained first from the Baldwin-Wood scales (1), and second from the Pryor standards (6).

Skeletal status was ascertained by means of roentgenograms of the left hand (anterior-posterior and lateral aspects), left foot (anterior-posterior and lateral aspects), left elbow (anterior-posterior aspect), and left knee (anterior-posterior aspect). These roentgenograms were used as follows:

(a) A maturation judgment was made on the hand and knee of each subject by comparing them with standards of children of the respective sex as selected by Todd (8) during an extensive study involving children of well-circumstanced families.

The difference between the chronological age of the child in the study and that of the child whose skeletal status seemed equivalent was designated as months of advancement or retardation in skeletal maturity.

(b) The ratio of the area of the ossific centers within the wrist to the wrist area, as determined by a method proposed by Baldwin, Busby, and Garside (2) at Iowa State University was ascertained by the use of a Coradi circumscribing disc planimeter. The ratio of the sum of the wrist ossific center areas to the wrist area, designated as the wrist ossific center index, or the wrist index, is presented as a measure of the growth of the secondary ossification centers in the wrist.

(c) A mineral density factor was obtained by making a tracing of the roentgenogram of the calcaneum between two fixed landmarks by means of a photographic recording photoelectric microphotometer as described by Mack, O'Brien, Smith, and Bauman (4), and by Mack and Smith (5).

A dental score was assigned to each child as a result of a clinical mouth examination, supplemented by roentgenograms, as based on an arbitrary rating scheme involving the degree and extent of caries and the condition of the soft tissues of the mouth.

Two calculations of slump were made for each child by comparing the horizontal with the standing heights and the stem end with the sitting height measurements. The percentage losses in height from changing from a recumbent to a standing position, and from the stem end to the sitting position are called the standing slump and sitting slump, respectively. Some investigators regard slump measurements as denoting muscle tonus, at least in a measure. In the present study, slump values are reported without regard to what they may represent.

The plantar contact values were obtained for each child in the study. The first was calculated as the ratio of the area of the sole of the foot of a subject touching a smooth, flat surface when he was sitting, in comparison with that touching when he was standing, and was reported as the plantar contact sitting / standing ratio. The second was an average of the percentages of the areas of the soles of the two feet touching when the subject was sitting, and was reported as the percentage of plantar contact. Preliminary work in the laboratory of the authors indicates that there may be some association between these two values and present or past nutritional history, but the evidence is not conclusive.

Hemoglobin was measured for each child by the Newcomer method, and reported in terms of grams of hemoglobin to 100 c.c. of blood.

Darkness adaptation was measured by means of a biophotometer. Tests were made with this instrument after 10 minutes in a darkroom; again after a five-minute period looking at the illuminated glass rectangle in the photometer; and after two and one-half, five, seven and one-half, and 10 minutes in subsequent darkness. The tests following bright light exposure were taken between 20 and 25 seconds after the bright light exposure was ended. The subjects were instructed concerning the test and the possible figures which they would see before the test was administered;

they were told to focus their eyes on the center dot of the quincunx when it was visible during the test. The method of calculating the biophotometer data was that described by Mack and Smith (5).

Capillary wall strength was ascertained by the method of Dalldorf (3).

For convenience, responses to each of the various tests have been grouped into five arbitrary classes. In each case, the limits of response to the test for Class 1 were set so as to include subjects believed in the light of present knowledge to be in optimum nutritional condition in the respect covered by the test. Class 5 included cases at the opposite extreme, as indicated by the analysis of the findings on approximately 2000 individuals. The intermediate classes were defined so as to divide the intervening range into convenient intervals. If the response to a certain test was known to be dependent upon sex or age, the definitions of the classes of response to the test were based upon findings for the respective sexes, and for series of chronological ages.

The limits of response to the tests included in the different classes are given in connection with the data which illustrate the distribution of the children with respect to the various tests.

RESULTS OF THE STUDY

The percentage distribution of the children throughout the class groupings for each of the tests is given in Table 1, and is shown graphically in Figures 2 to 13.

Nutritional Status by Physical Examination. The definition of 85 points and over for Class 1 for nutritional status by physical examination concurs with the over-all examination by certain pediatricians accustomed to advise parents on the diet of children, who base their decisions on a subjective estimate of what the appearance of a child in optimum nutritional condition should be. Although no child fell within this class in this unit of the series of studies of which this is a part, some children in other units of the study have received scores which placed them in this class. As is seen in Figure 2, the majority of the children in this study were divided between Class 2 and Class 3 with respect to this physical examination score. Although no child was included in the study who was adjudged by a physician as exhibiting pathological manifestations, 10.8 per cent of the children were scored so low on the various items within the physical examination rating scheme that they fell within Class 4, while only 0.3 per cent were found in the extreme Class 5 group, including those rating 40 points or less.

Weight Status. Although the use of height-weight measurements is common throughout the schools of this country as a means of comparing a child's weight with norms representing the average of children of the same height, weight, and sex, it is doubtful that this measure is valuable for research purposes, because: 1) no objective criterion of normality was available to those preparing such scales; 2) body width is not taken into consideration; and 3) the tables represent average and not optimum body height-weight relations.

The Baldwin-Wood scale is subject to the three objections listed above, and was intended by the investigator introducing it as a method of ascertaining whether a child was growing by measuring him from time

TABLE 1

PERCENTAGE DISTRIBUTION OF CHILDREN WITH RESPECT TO THE VARIOUS NUTRITION TESTS

Nutritional Tests	Class 1	Class 2	Class 3	Class 4	Class 5
Appearance of Nutritional Status by Physical Examination	0.0%	30.8%	58.1%	10.8%	0.3%
Weight Status according to the Baldwin-Wood Standards	67.9	a) 18.9 b) 0.8	a) 7.8 b) 1.0	a) 2.3 b) 0.0	a) 0.5 b) 0.8
Weight Status according to the Pryor Standards	53.4	a) 23.9 b) 1.6	a)12.8 b) 0.5	a) 5.9 b) 0.0	a) 1.6 b) 0.3
Skeletal Status					
Maturity according to Todd Standards	51.2	10.6	12.9	12.2	12.9
Wrist Ossific Center Index	32.7	25.7	23.2	11.3	7.1
Mineral Density Factor	7.4	14.5	18.3	24.4	35.4
Dental Status by Clinical Examination supplemented by Dental X-rays	2.5	22.6	43.9	24.5	6.3
Slump, Standing	91.8	7.2	0.4	0.4	0.0
Sitting	15.7	29.3	42.9	10.1	1.8
Plantar Contact					
Ratio Sitting / Standing Areas	90.5	6.4	2.8	0.0	0.2
Average Sitting Percentages	36.4	37.5	21.2	4.9	0.0
Hemoglobin, in Grams per 100 c.c. blood	1.2	41.2	44.0	13.3	0.2
Biophotometer, Bright Light Factor	9.4	16.9	32.2	35.3	6.1
Darkness Regeneration Factor	20.8	49.2	12.1	8.3	9.5
Total Integration Factor	3.2	36.9	28.9	23.9	6.9
Capillary Wall Strength	37.8	26.8	25.0	8.9	1.4

to time, rather than to ascertain whether he was the proper weight for his height at any given time. Nevertheless, the scales are used extensively throughout the public schools, and the children of this study were compared therewith in order to see how they were distributed on the basis of supposedly normal weight, under-weight, or over-weight in comparison with these averages.

As is seen in Figure 3, Class 1 contained 67.9 per cent of the children in the study; this class consists of children in which the weight was within 10 per cent above or below that shown in the scale for the sex and height of the subject in question. Classes 2(a), 3(a), 4(a) and 5(a), consisting of children within the under-weight limits shown in the table, comprised 18.9, 7.8, 2.3, and 0.5 per cent of the children, respectively. Classes 2(b), 3(b), 4(b) and 5(b), representing over-weight classes as shown in the table, contained but 0.8, 1.0, 0.0, and 0.8 per cent, respectively, of the children in the study. It is evident, therefore, that over-weight was not relatively frequent in occurrence, while 29.5 per cent of the children were under-weight according to this scale. Since this series of standards was based upon a large number of school children, without regard for optimum nutritional status, it is possible

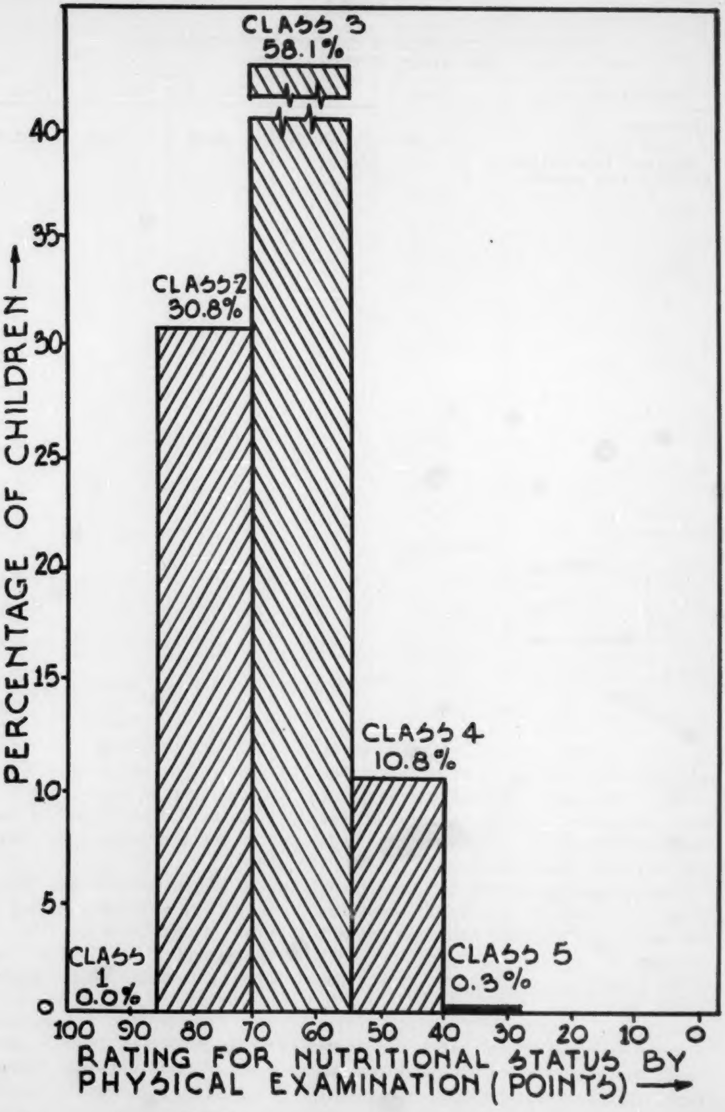

Fig. 2. Percentage Distribution of the Children as to their appearance of Nutritional Status by Physical Examination.

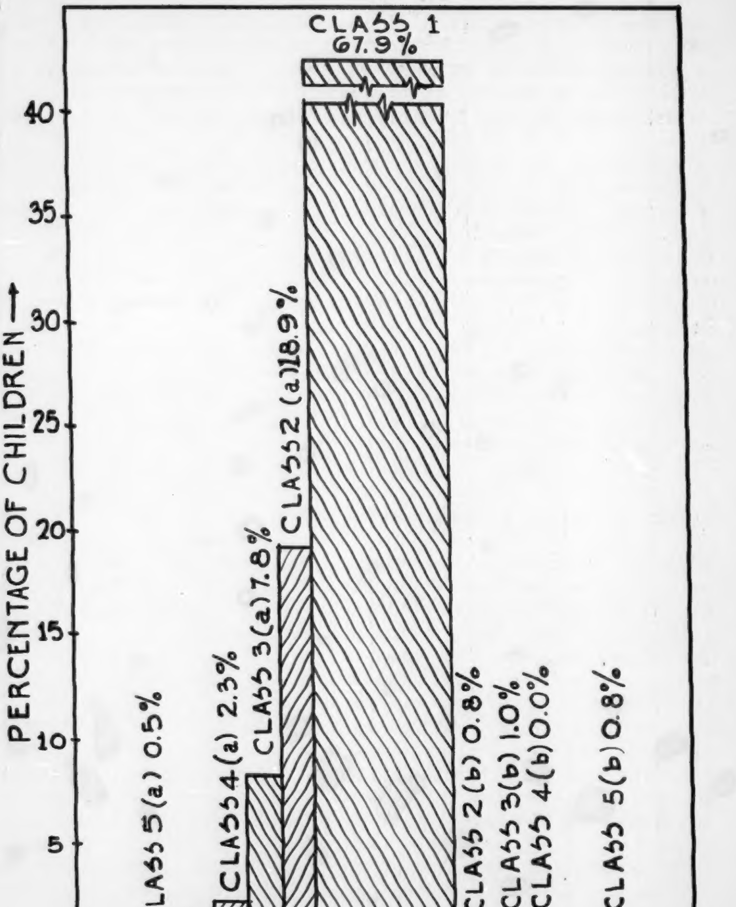

Fig. 3. Percentage Distribution of the Children as to Weight Status as Ascertained by the Baldwin-Wood Scale.

that the percentage of children deviating from an optimum weight for their sex, age, and height was greater than is indicated in this figure.

The Pryor standards, which involve considerations of height, weight, and iliac width of children of the two sexes and of various ages, are not subject to one of the criticisms of the Baldwin-Wood scale, in that a width measurement is included. Figure 4, in which the percentage distribution of the children on the basis of their percentage weight deviation from the standards for their respective sexes, ages, heights, and iliac widths, shows that 53.4 per cent of the children in the study fell within Class 1 according to the Pryor standards. Most of the remainder of the children (44.2 per cent) were in the under-weight classes, which means that they were more than 10 per cent under-weight. Only 2.4 per cent of the children were in the over-weight classes.

Skeletal Status. When the roentgenograms of the children were assayed as to skeletal maturation status by comparing them with Todd standards for hand and knee, it was found that only 51.2 per cent of the children were in Class 1, because they compared satisfactorily with the Todd standards of children of the same sex and age, within six months of the same, chosen by Todd from large numbers of roentgenograms of children with good nutritional histories and from well-to-do families. The remaining children in the study were distributed almost equally among the four lower maturity classes, as is shown in Figure 5.

The wrist-index class distribution is shown in Figure 6. Here it is seen that Class 1 contained 32.7 per cent of the children, with a decreased percentage in each successive class. The arbitrary standards for the classes in this case were set by the authors from a study of the responses (to this test) of a large number of children of various ages and both sexes. As in the other classifications for factors in which age and sex differences pertain, limits were set for age and sex groups for Class 1 so that children which were believed to be optimum in this respect were included. The values for children at the opposite extreme were placed in Class 5, and convenient intervals were established for the intervening classes, for each sex and age classification.

A different story is told by the results of the mineral index classifications, in Figure 7. Whereas the maturity classes as ascertained by comparison with the Todd standards had approximately half of the children in Class 1, and the ratio of the areas of wrist ossific centers to wrist areas were such that about one-third of the children were in the optimum class, only 7.4 per cent of the children were found in Class 1 with respect to skeletal mineralization; the mineralization classes were based upon the findings for about 2000 children, distributed as has been stated, through a wide socio-economic range, whereas the children of this study were chiefly at the middle and lower end of the scale with respect to cash income and family education.

The significance of each of the three skeletal status tests applied in this study has not yet been established. In selecting his maturation standards, and in training others in their use, Todd has stressed the point that evidences of maturity as apart from mere growth or size should serve as the criteria for judging maturation status. He has decried the use of areas, or other measures of ossific center size as indices of maturity, stating that the forlorn hope of judging maturation by this

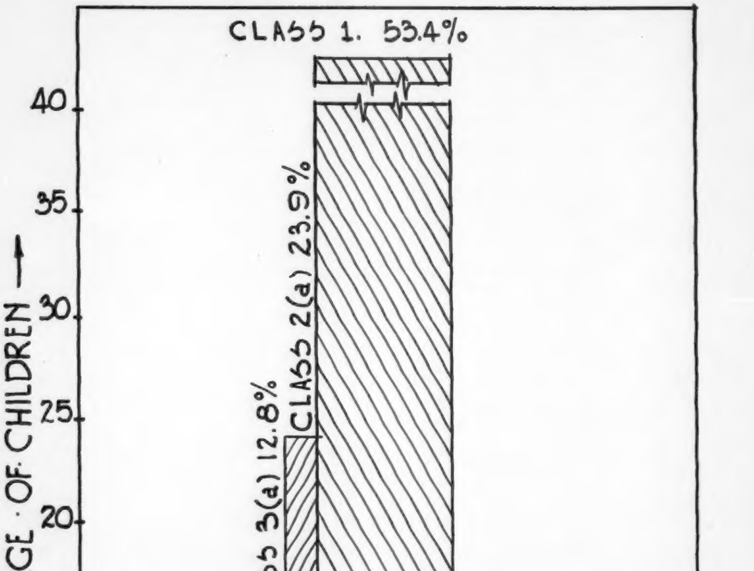

Fig. 4. Percentage Distribution of the Children as to Weight Status as Ascertained by the Pryor Scale.

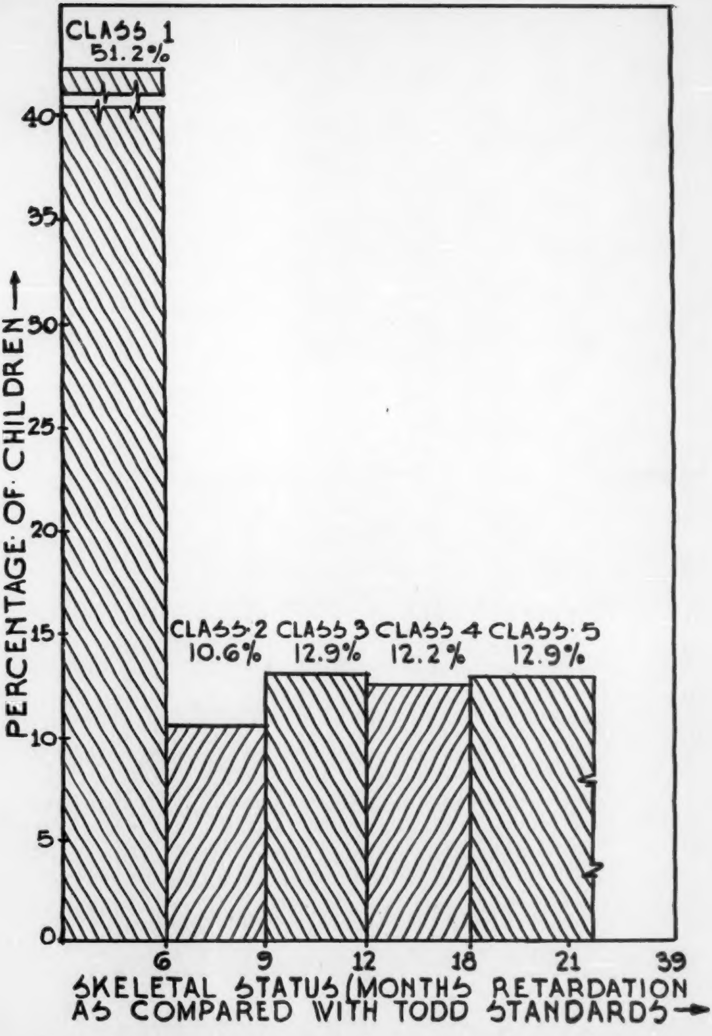

Fig. 5. Distribution of the Children as to Skeletal Maturity as Measured by the Todd Standards. Class 1 represents children who are not retarded more than 6 months as compared with these standards; Class 2 represents children retarded from 6 to 9 months; Class 3 from 9 to 12 months; Class 4 from 12 to 18 months, and Class 5 those retarded more than 18 months.

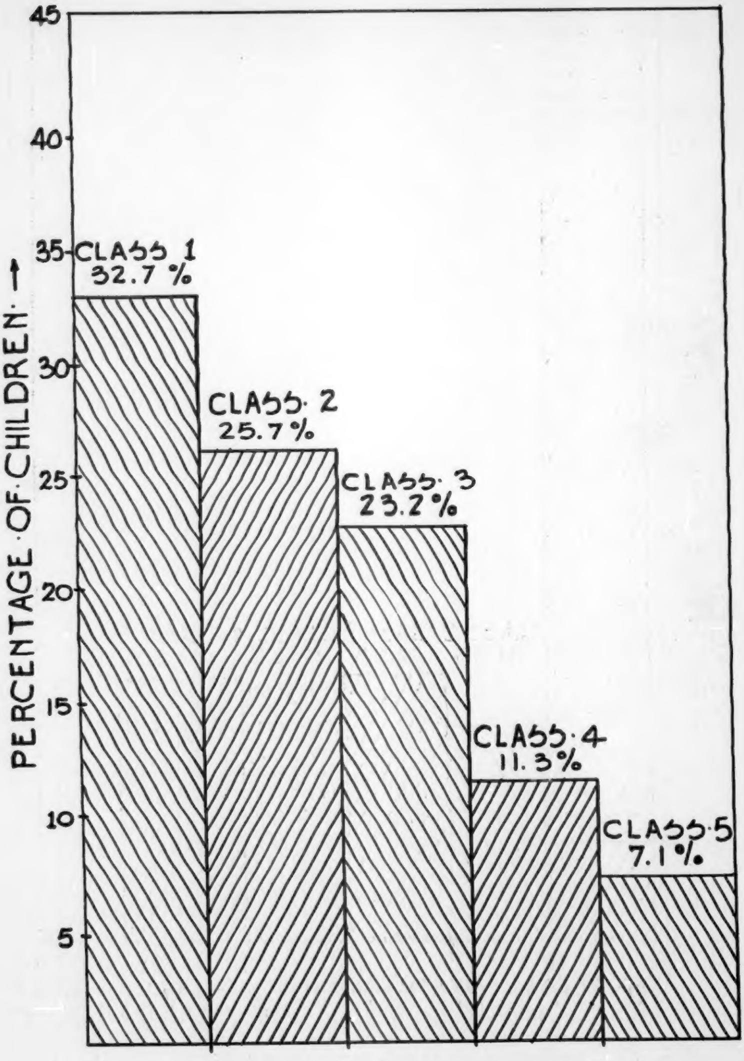

Fig. 6. Distribution of the Children as to Skeletal Status as Ascertained by the Wrist Ossific Center Index.

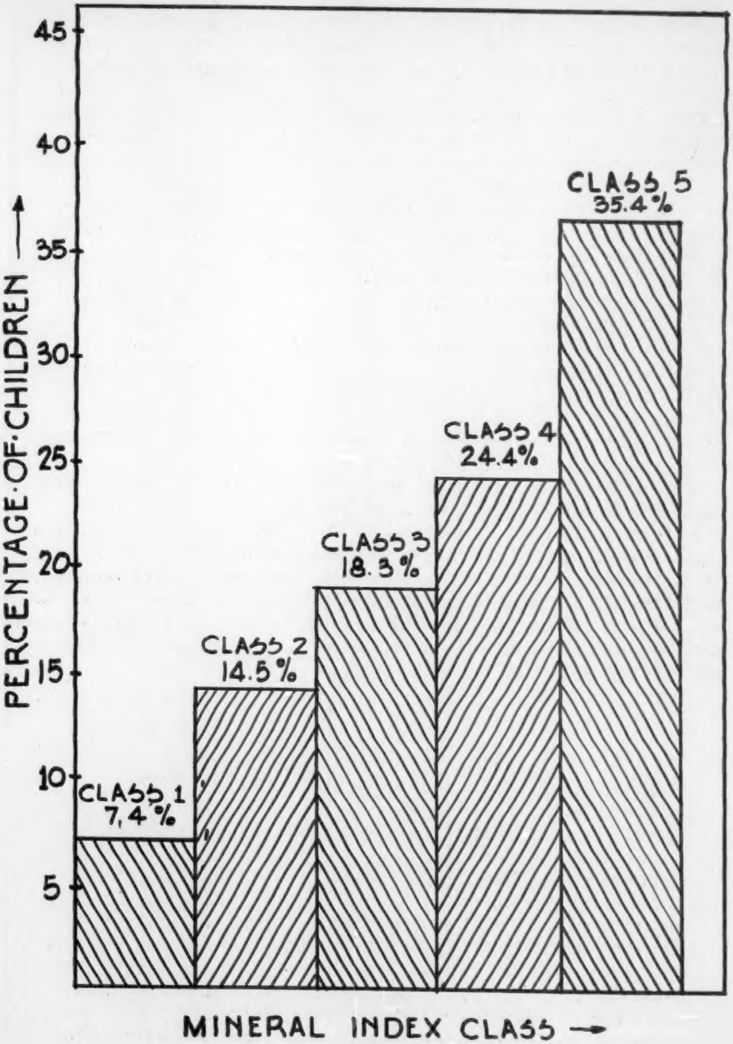

Fig. 7. Distribution of the Children as to Degree of Skeletal Mineralization.

method is based upon the erroneous confusion of maturity with growth. Baldwin, Busby, and Garside (2) on the other hand have used the wrist ossific center index as a measure of physiological growth, a concept which appears to involve not only growth but maturation as well. In using the latter factor (wrist index) in this study, it was not the purpose of the authors to accept it either as a strict measure of maturation or of growth, but rather to find, through this and other studies of this series, with what other nutritional test response factors and nutrient consumption factors it might be related.

In this study, it has been found: 1) that the maturity values as measured by the Todd standards are correlated with the wrist ossific center indices, the coefficient of correlation being $+0.359 \pm 0.03$; 2) that the maturity values as measured by the Todd standards are correlated with the mineral indices, with a coefficient of correlation of $+ 0.2222 \pm 0.03$; and 3) that the wrist ossific center values are correlated with the mineral indices, with a coefficient of correlation of $+ 0.6504 \pm 0.02$. Details of this comparison will be reported in a separate publication.

For the sake of discussion at this point, it may be tentatively assumed that the three processes of skeletal maturation, growth, and mineralization may be simultaneously both related and competing processes, and that they are represented at least partially by the index of maturity according to the Todd standards, the wrist ossific center index, and the mineral index, respectively. It is further assumed by virtue of the method of setting the arbitrary standards that Class 1 represents the optimum for each of the factors, with the other classes representing approximately the same degree of sub-optimum status in each case. On the basis of these assumptions, a scrutiny of the data of this study will show to what extent the classification of each of these three factors is the same as, above, or below the others.

	Percentage of Children
Maturity status (Todd) <u>same class as</u> Wrist Ossific Center Index	30.9%
Maturity status (Todd) <u>above</u> Wrist Ossific Center Index	42.0
Maturity status (Todd) <u>below</u> Wrist Ossific Center Index	27.1
Maturity status (Todd) <u>same as</u> Mineral Index	17.6
Maturity status (Todd) <u>above</u> Mineral Index	68.4
Maturity status (Todd) <u>below</u> Mineral Index	14.0
Wrist Ossific Center Index <u>same as</u> Mineral Index	14.1
Wrist Ossific Center Index <u>above</u> Mineral Index	69.1
Wrist Ossific Center Index <u>below</u> Mineral Index	16.4

From this there is evidently a greater tendency for maturation as measured herein to approach Class 1, or the optimum status, than for the growth of ossific centers, or for the mineralization of bones to do so. Whether or not the ratio of ossific center areas of the wrist to the wrist area is more representative of growth than of maturation, it is

apparently associated both with maturation and mineralization, and is intermediate between the two with respect to the approach to the optimum class of children in a community in which low incomes, and consequent poor diets prevail.

Dental Status. The rating system for dental status was an arbitrary one, based upon the incidence and extent of caries and upon the condition of the soft tissues of the mouth. Class 1 in this rating included children in whom dental caries was absent, as determined by clinical examination supplemented by roentgenograms, and whose mouth tissues were in excellent condition. Figure 8 shows that the children were widely distributed throughout the dental status class range, and that the middle class included a considerably greater percentage than did any of the other classes.

Slump. When the children were classified as to standing slump, 91.8 per cent were found in Class 1, as is seen in Figure 9. When classified as to sitting slump, only 15.7 per cent were found in Class 1, with the greatest number of the cases in Class 3. Since the limits of the various classes were the same both for standing and sitting slump - i.e., the same percentage losses in height (standing or stem end) - were assigned in the two cases, the difference in the distribution is obvious. A greater opportunity for loss in height occurs in the upper part of the body as well as a probably greater tendency to slump when one is sitting than when he is standing. The significance of this test has not yet been established, although there is an indication that it may be related in extreme cases to certain nutritional conditions.

Plantar Contact. In the series of plantar contact ratings based on the numerical ratio of the area of the sole of the foot touching the supporting surface while the subject was sitting to that touching while he was standing, 90.5 per cent of the children were found in Class 1, as is seen in Figure 10. In the classifications based upon the percentage of the foot touching while sitting as compared with the area of the entire sole, however, only 36.4 per cent were found in Class 1, with 37.5 per cent in Class 2, and the remainder in the three lower classes.

Hemoglobin Status. Only 1.2 per cent of the children were in Class 1 with respect to hemoglobin status, as is seen in Figure 11, with 13 grams of hemoglobin per 100 c.c. of blood, or more. In Class 2, with hemoglobin values ranging between 12.9 and 11.5 grams per 100 c.c. of blood, 41.2 per cent of the children were found; 44.0 per cent were in Class 3 having values between 11.4 and 10.0 grams per 100 c.c.; 13.3 per cent were in Class 4 with values between 9.9 and 7.5 grams per 100 c.c.; and none of the children of this study were in Class 5, with values below 7.5 grams per 100 c.c.

Darkness Adaptation Status. According to the bright light factor as obtained by the use of the biophotometer, Figure 12, only 9.4 per cent of the children were in Class 1, while 41.4 per cent were in the two lowest classes. A subsequent study with these same children was made, to be reported later, in which vitamin A concentrates were administered for a period of time to some of the children in each of the initial classes. The average biophotometer bright light factors, as well as the various other biophotometer factors, of all of the groups of children save those in the highest classes were raised by this administration - a

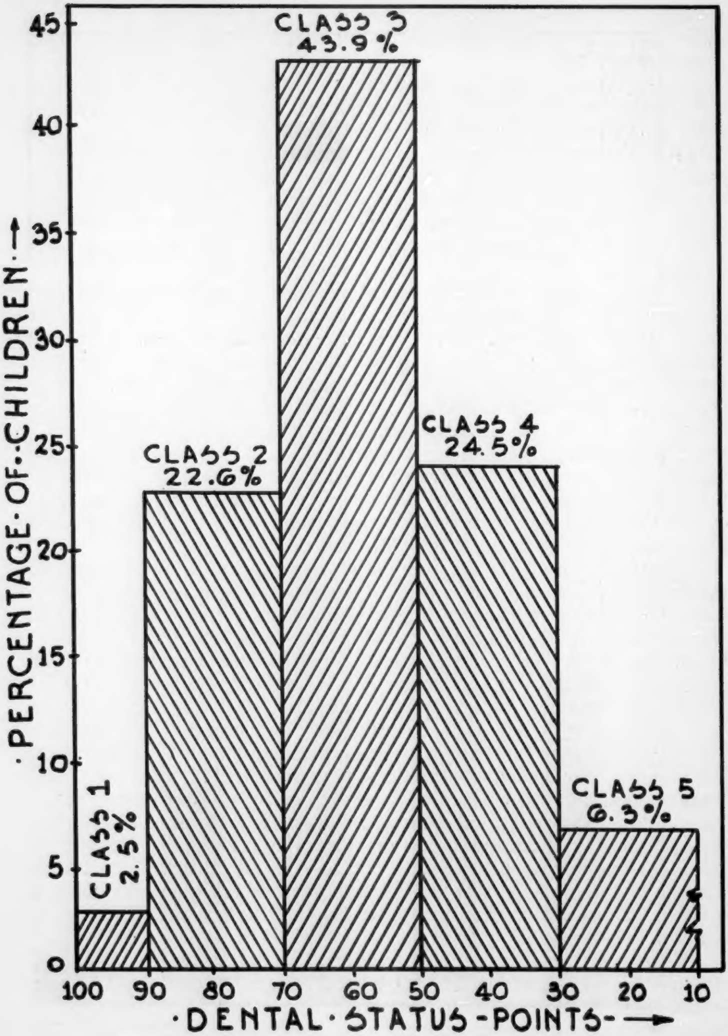

Fig. 8. Distribution of Children as to Dental Rating.

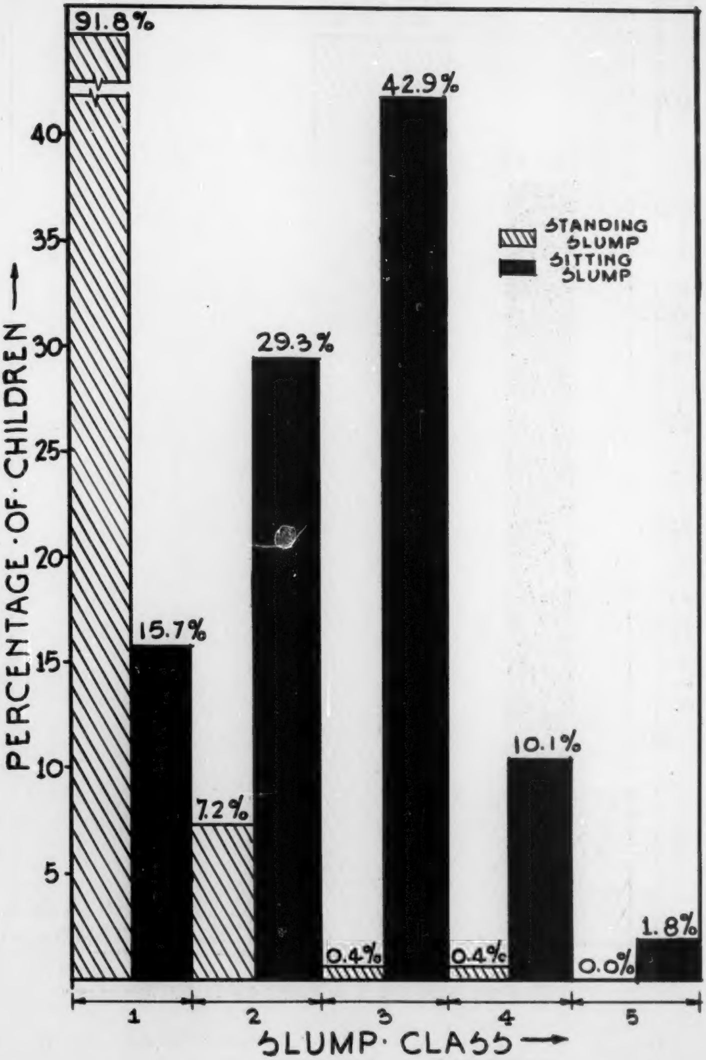

Fig. 9. Distribution of Children as to Standing and Sitting Slump.

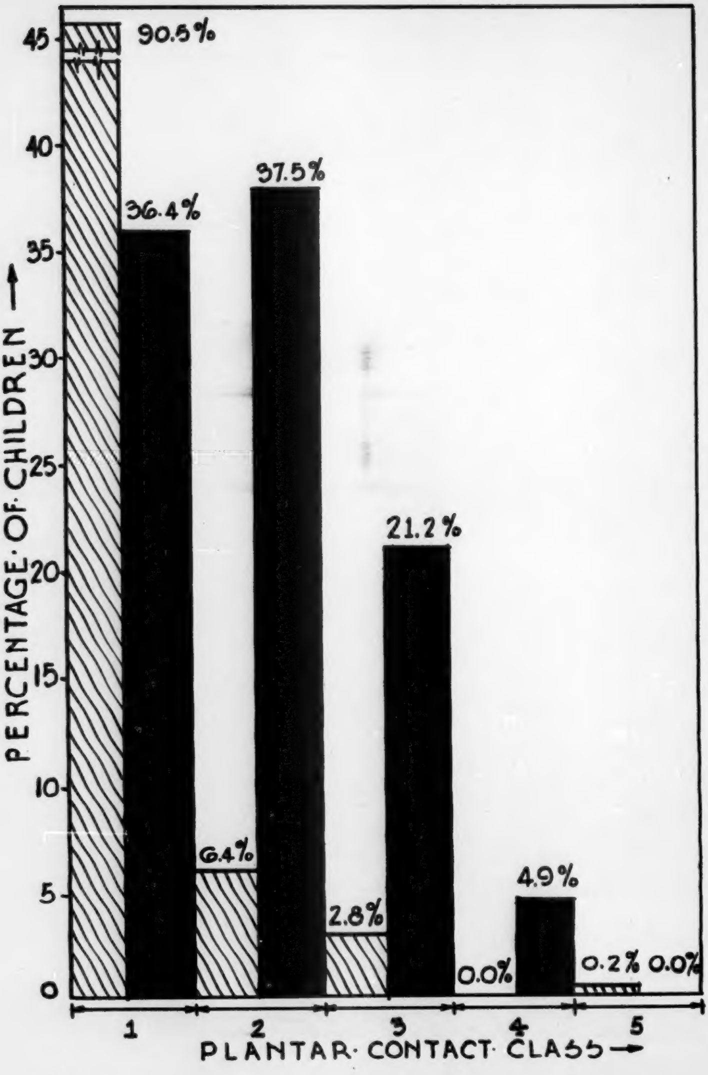

Fig. 10. Distribution of Children as to Plantar Contact Status:
(1) as indicated by the ratio of contact while sitting to that of standing;
(2) as indicated by the percentage of plantar contact while sitting.

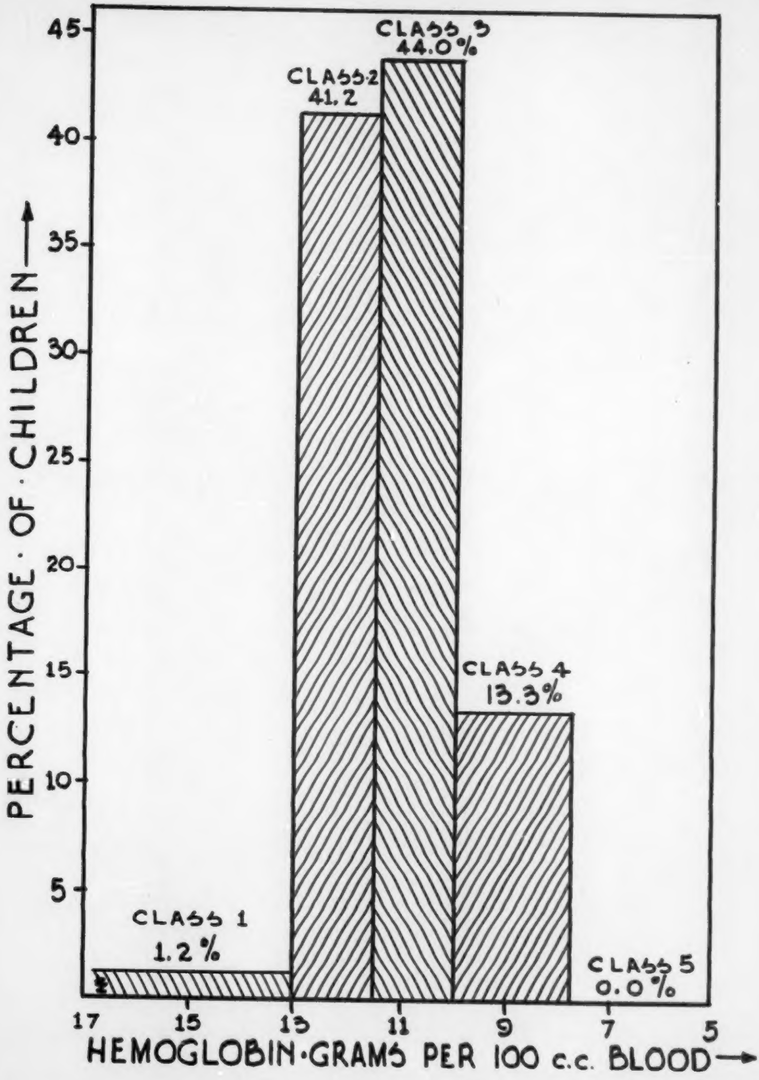

Fig. 11. Percentage Distribution of Children as to Hemoglobin Status.

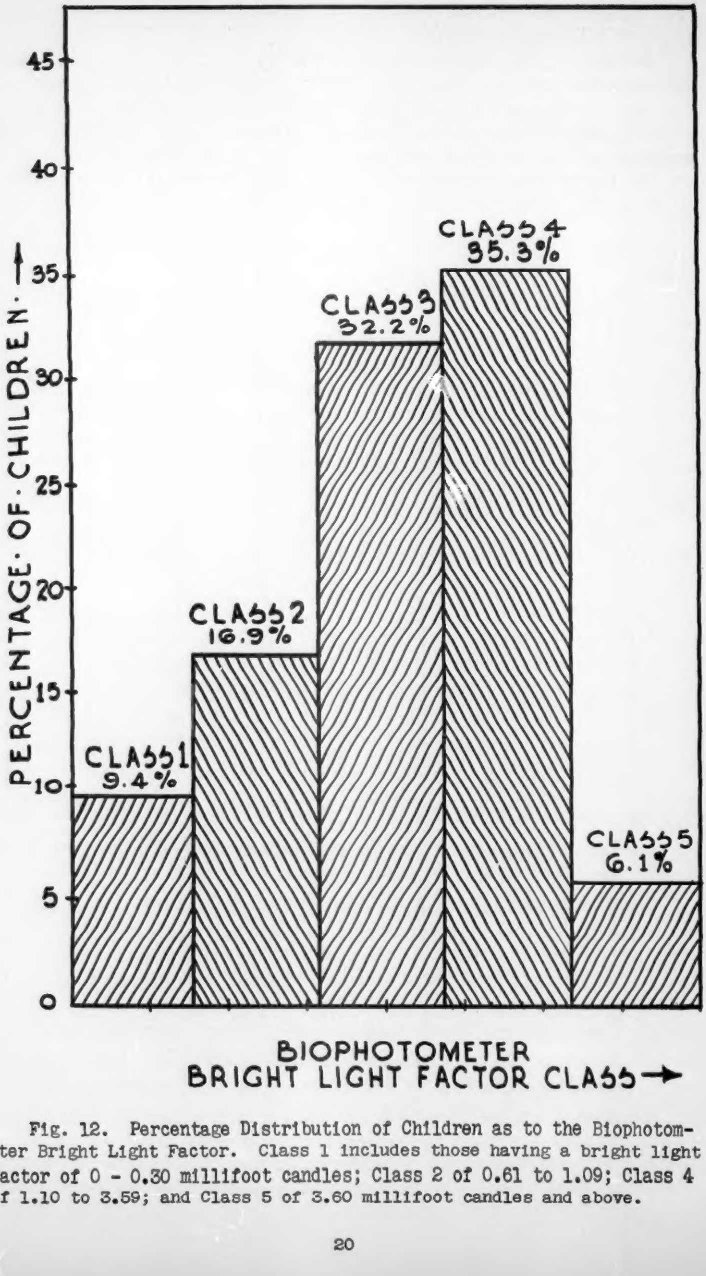

Fig. 12. Percentage Distribution of Children as to the Biophotometer Bright Light Factor. Class 1 includes those having a bright light factor of 0 - 0.30 millifoot candles; Class 2 of 0.61 to 1.09; Class 4 of 1.10 to 3.59; and Class 5 of 3.60 millifoot candles and above.

fact which attests further to the low status of these children with respect to darkness adaptation.

In Table 1, the distributions of the children on the basis of two biophotometer factors other than the bright light factor have been given. A higher percentage of the children were in Class 1 on the basis of the darkness regeneration factor, which is obtained at the end of the final darkness period, than was the case with the bright light factor. Even so, the proportion of children in this class was not large, being only 20.8 per cent. On the basis of the total integration factor, a value representing the area under the curve for the entire series of biophotometer tests, a strikingly small number of children were in the better classes.

Capillary Wall Strength. The possible significance of the capillary wall strength test has been discussed by Sybil Smith (7). Probably this test indicates severe degrees of vitamin C under-nutrition, as well as general nutritional status. Besides the implications of the results of this test, Figure 13 shows that 37.8 per cent of the children in this study were classed in the highest group, with progressively smaller percentages found in the succeeding groups. In some groups of privileged children in the larger study of which this is a unit, 100 per cent of the children have been found in Class 1 with respect to response to this test.

Socio-Economic Status and Response to Nutrition Tests - Income of Family. The cash incomes of the families of the children did not appear to be related to their average ratings in the following cases:

Weight Status Classes (There was no association of income class with deviation from the standard for both under-weight and over-weight combined. A tendency was shown, however, for a greater degree of under-weight in the families with lower incomes.);

Dental Status Classes;

Slump Classes; and

Capillary Wall Strength.

The family cash incomes were apparently related, on the other hand, to the responses to the following tests:

Appearance of Nutritional Status by Physical Examination - the average points were higher for Income Classes A and B combined than for Class C, and Classes D and E combined. There were no significant differences, however, between the averages of Class C and of Classes D and E combined.

Skeletal Status - The average classes for all three skeletal status factors for children within the different income groups became progressively poorer as the income classes became lower.

Hemoglobin Status - The average grams of hemoglobin per 100 c.c. of blood was 12.04 for Income Classes A and B combined, 11.51 for Income Class C, and 11.04 for Income Classes D and E, combined. A highly significant difference was shown between

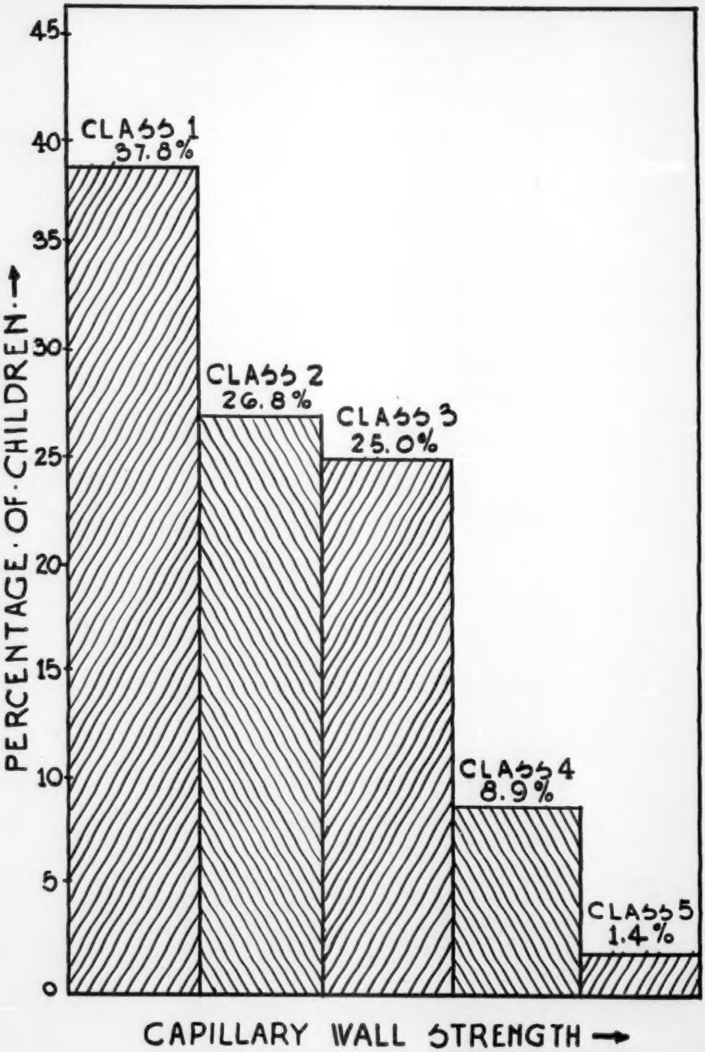

Fig. 13. Percentage Distribution of Children as to the Capillary Wall Strength.

Income Classes A and B combined, when compared with D and E combined, with odds greater than 100:1 that the difference did not occur by chance. Slightly significant differences (Odds 20:1) were established between the combined A and B classes and the C class, and between the C class and the combined D and E Income classes.

Darkness Adaptation Status - A tendency toward a lower average biophotometer rating with a lower income was shown for all of the biophotometer factors used. The greatest difference, however, was established between the darkness regeneration factor, or the response to the test at the end of the 10-minute darkness regeneration period.

Education of Family Adults. Although the children were chosen on the basis of their family income, and not of their family education, a highly significant correlation was established between the cash incomes of the families of the children and the degree of formal education of the adult family members. The following was the percentage distribution of the families on the basis of the arbitrary education classes previously defined:

Education Class A	0.5%
Education Class B	7.5
Education Class C	2.6
Education Class D	7.9
Education Class E	81.3

The average responses to the tests when the children were classified on the basis of the family educational rating showed the same tendencies as those shown when they were grouped according to cash incomes.

Children's Dietaries. An analysis of the dietaries of the children in this study will be given in greater detail in a later publication. A summary of the weekly intake of the chief dietary items by income classes follows in Table 2.

From the data in Table 2, it is seen that a sharp drop with a decreasing income was shown in the consumption of the items of diet most likely to be associated with the so-called protective foods. Thus, milk and meat were consumed in less than half the per capita quantity by children in the two lower income groups combined than by those in the two upper groups, with egg consumption falling to about 65 per cent that of the higher income groups. The consumption of citrus fruits by the two lowest income groups combined was less than one-third that by the two highest groups. Other fruits did not show this drop. The consumption of green vegetables and of yellow vegetables fell sharply and tomatoes slightly with decreasing incomes, while bread and potatoes were consumed in somewhat larger quantity by children in the lower income groups.

This finding, coupled with the fact that responses to certain of the nutritional tests related to the consumption of the protective foods were poorer in the lower income groups points to the desirability of making a free or low-priced school lunch available to children in these income brackets. It shows further the lack of wisdom in following the

TABLE 2

WEEKLY AVERAGE DIETARY INTAKE OF CHILDREN BY INCOME CLASSES

Summary of Food Intake per Week	Income Classes		
	A and B Combined	C	D and E Combined
Milk, quarts	4.6	3.3	2.2
Meat, servings	4.8	3.7	2.9
Eggs, besides in cooking	2.8	2.3	1.8
Citrus fruit, servings	3.8	2.8	1.2
Other fruit	4.9	5.5	4.3
Vegetables, Potatoes	4.5	5.0	5.6
Green	5.7	3.8	2.7
Yellow	2.4	1.1	1.6
Tomatoes	2.6	2.0	2.1
Bread, slices per day	6.6	7.0	7.0

tendency of making such a lunch high in energy without especial regard for the protein, mineral, or vitamin content thereof, since the home diets of the low income children in the study (none of them ate at a school lunch) indicate the soundness of the reverse policy.

SUMMARY

A study was made of the dietary habits and nutritional status of 428 representative children in an industrial city of about 82,000 inhabitants, where low incomes prevailed. Nine tests for nutritional status were applied, and the percentage distribution of the children with respect to these tests was presented graphically. The relationship of the responses to the tests and the socio-economic status of the child's family as measured by cash income and education of adult members was discussed, as well as the significance of the consumption of the main items of food by children in the different income groups.

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FACTORS IN THE GROWTH OF GIRLS[1]

FRANCES A. MULLEN[2]

The intercorrelations of seventeen physical measurements of girls of various age groups have been analyzed to determine: 1) the portion of the variance at each age which may be ascribed to a general growth factor; 2) the group and special factors which may be necessary to account for the residual correlations at each age; 3) whether one estimate of the general and group factors may be used at all ages, in the study of the growth of the factors, and 4) the relationship of such factors, both general and group, to the age at which puberty occurs.

The intercorrelations have been analyzed by the bi-factor technique developed by Holzinger (4). This method of factor analysis assumes a general factor to account for the positive character of the correlational matrix, and independent group factors to account for higher correlations within a restricted group of measurements than would be produced by the general factor alone. To the general factor is ascribed as much of the variance of each individual measure as is consonant with the magnitude of the correlation coefficients and with the postulated group factors. The residual correlations are then accounted for by group factors which are the general factors common to a restricted group of residuals, and by special factors for each measurement.

The analysis presented in this paper will show that it is possible to obtain an excellent fit to the present correlation tables by such an assumption of general, group, and special factors, all independent of each other. It would have been possible, however, to have postulated group factors without a general factor, even though the correlations are all positive. In such a case the group factors must either overlap, as they do in most multiple factor analyses, where each factor has loadings in practically all of the measurements, or the group factors must themselves be correlated, not independent. The choice between these methods of factoring the observed correlations must be made not on mathematical grounds but in view of such questions as: Which method gives the most understandable and parsimonious description of the factors? Which analysis gives results of most use to the geneticist or student of child development in his effort to understand the underlying phenomena?

The subjects of the study are girls enrolled in the Laboratory Schools of the University of Chicago. The measurements, made by physicians on the staff of the schools during the years 1927-37, are as follows: height, arm span, length of right forearm, length of right lower leg, sitting height, weight, bi-iliac diameter, bi-trochanteric diameter, chest girth, chest width, chest depth, shoulder width, head length, head width, head height, lung capacity, and right hand squeeze. The technique used in making and recording each measurement is described by Bolmeier (1). The measurements were made as nearly as possible on the date of the child's birthday. For the records used in this study the average date of

[1]*The writer wishes to acknowledge her indebtedness to Dr. Karl J. Holzinger, under whose direction this study was carried out, and to Dr. Frank N. Freeman, who made available the records of the Laboratory Schools of the University of Chicago.*

[2]*From the Bureau of Child Study, Board of Education, Chicago.*

examination was 2.005 days after the birthday, with a mean deviation of 6.24 days. Since each age group is treated separately, age is well controlled and need not be allowed for statistically.

The study is limited to girls of the ages of seven, nine, eleven, thirteen, fifteen, and seventeen. All records in the files for girls of these ages were used in this study if they were complete in the seventeen selected measurements, with the exception of seven records discarded because of inconsistencies.

The 136 possible intercorrelations of the seventeen measurements at each age level were computed by the product-moment technique. In analyzing the resulting correlational matrices, two clusters of variables became evident. The five variables: height, arm span, length of right forearm, length of right lower leg, and sitting height have at all ages higher intra-group than extra-group correlations. Similarly, the seven variables: weight, the two hip measures, the three chest measures, and shoulder width, form a second cluster. The identification of these clusters was made by the use of the B-coefficient (4, p. 23) and verified by the goodness of fit of the resulting factor patterns. Sitting height, however, proved on further study to be related to the first group largely through its high correlation with standing height and to have insignificant factor loadings with the first group factor. Similarly shoulder width is the most doubtful member of the second group. No grouping could be set up among the remaining five variables.

At most age levels, four correlations appeared to be significantly higher than could be accounted for by the general and group factors here postulated. In the final calculations of the factor loadings, the results of which are shown in Tables 1 to 6, allowance was made for these overlaps.

The entries in these tables may be interpreted in several ways. Each factor loading is the correlation of the given variable with the hypothetical factor. Each loading is also the square root of the proportion of the total variance of a given measure which may be ascribed to that factor. Finally, the correlation between any two variables should be reproduced by the sum of the products of the factor loadings which the two variables have in common.

The various measures correlate much more highly with the general factor than they do with the two group factors. For the last five measures, however, and for some of the second group of measures, a large part of the variance cannot be ascribed to general or group factors, or to doublets, but must be accounted for by factors unique to each measure.

To check the accuracy with which the factor patterns fit the observed correlations, the differences between the theoretical correlations (computed from the sum of the products of the loadings of such factors as the two variables have in common) and the observed correlations have been computed. It should not be expected that these residuals will all be exactly zero, but they should distribute around zero. The means and variabilities of the residuals for each age are shown in Table 7. It will be noted that .6745 times the standard deviation of each of these distributions is less than the probable error of a zero correlation for a population of the size of each of these age groups.

The probable error of a zero correlation has been suggested as a

TABLE 1

FACTOR LOADINGS FROM THE CORRELATIONS BETWEEN SEVENTEEN PHYSICAL MEASUREMENTS OF 189 SEVEN-YEAR-OLD GIRLS

Variables	α	β	γ	D_1	D_2	D_3	D_4	ω_i
Height	.878	.372	-	-	-	-	.000	.301
Arm span	.797	.488	-	.000	-	-	-	.356
Forearm	.756	.568	-	-	-	-	-	.326
Lower leg	.823	.440	-	-	-	-	-	.359
Sitting height	.832	.000	-	-	-	-	.000	.555
Weight	.834	-	.445	-	-	-	-	.326
Bi-iliac diameter	.677	-	.451	-	-	-	-	.581
Bi-trochanteric "	.744	-	.488	-	-	-	-	.456
Chest girth	.682	-	.466	-	-	-	-	.564
Chest width	.590	-	.432	-	-	-	-	.682
Chest depth	.527	-	.336	-	-	-	-	.780
Shoulder width	.703	-	.200[a]	.000	-	-	-	.682
Head length	.398	-	-	-	.444	-	-	.803
Head width	.352	-	-	-	-	.270	-	.896
Head height	.323	-	-	-	.444	.270	-	.791
Hand squeeze	.299	-	-	-	-	-	-	.954
Lung capacity	.397	-	-	-	-	-	-	.918
Total variance	7.273	.893	1.196	.000	.394	.146	.000	7.096
Per cent variance	42.8	5.4	7.0	.0	2.3	.9	.0	41.7

[a] Insignificant.

TABLE 2

FACTOR LOADINGS FROM THE CORRELATIONS BETWEEN SEVENTEEN PHYSICAL MEASUREMENTS OF 212 NINE-YEAR-OLD GIRLS

Variables	α	β	γ	D_1	D_2	D_3	D_4	ω_i
Height	.840	.424	-	-	-	-	.210	.266
Arm span	.792	.510	-	.179	-	-	-	.284
Length of forearm	.796	.543	-	-	-	-	-	.268
Length of lower leg	.868	.318	-	-	-	-	-	.382
Sitting height	.773	.049[a]	-	-	-	-	.210	.597
Weight	.768	-	.542	-	-	-	-	.341
Bi-iliac diameter	.668	-	.487	-	-	-	-	.563
Bi-trochanteric "	.611	-	.642	-	-	-	-	.464
Chest girth	.582	-	.598	-	-	-	-	.551
Chest width	.544	-	.521	-	-	-	-	..658
Chest depth	.465	-	.565	-	-	-	-	.682
Shoulder width	.626	-	.346	.179	-	-	-	.676
Head length	.482	-	-	-	.438	-	-	.759
Head width	.248	-	-	-	-	.300	-	.921
Head height	.291	-	-	-	.438	.300	-	.796
Hand squeeze	.544	-	-	-	-	-	-	.839
Lung capacity	.514	-	-	-	-	-	-	.858
Total variance	6.908	.838	2.011	.064	.384	.180	.088	6.531
Per cent variance	40.6	4.9	11.8	.4	2.3	1.1	.5	38.4

[a] Insignificant.

TABLE 3

FACTOR LOADINGS FROM THE CORRELATIONS BETWEEN SEVENTEEN PHYSICAL MEASUREMENTS OF 230 ELEVEN-YEAR-OLD GIRLS

Variables	α	β	γ	D_1	D_2	D_3	D_4	ω_i
Height	.888	.344	-	-	-	-	.207	.224
Arm span	.863	.403	-	.017	-	-	-	.304
Length of forearm	.857	.472	-	-	-	-	-	.207
Length of lower leg	.871	.338	-	-	-	-	-	.356
Sitting height	.833	.000	-	-	-	-	.207	.513
Weight	.784	-	.536	-	-	-	-	.313
Bi-iliac diameter	.735	-	.495	-	-	-	-	.464
Bi-trochanteric "	.750	-	.529	-	-	-	-	.397
Chest girth	.755	-	.467	-	-	-	-	.460
Chest width	.628	-	.595	-	-	-	-	.502
Chest depth	.551	-	.499	-	-	-	-	.669
Shoulder width	.680	-	.255	.017	-	-	-	.687
Head length	.401	-	-	-	.381	-	-	.833
Head width	.237	-	-	-	-	.363	-	.901
Head height	.378	-	-	-	.381	.363	-	.762
Hand squeeze	.599	-	-	-	-	-	-	.801
Lung capacity	.577	-	-	-	-	-	-	.817
Total variance	8.220	.618	1.698	.006	.290	.264	.086	5.825
Per cent variance	48.4	3.6	10.0	.0	1.7	1.5	.5	34.3

TABLE 4

FACTOR LOADINGS FROM THE CORRELATIONS BETWEEN SEVENTEEN PHYSICAL MEASUREMENTS OF 219 THIRTEEN-YEAR-OLD GIRLS

Variables	α	β	γ	D_1	D_2	D_3	D_4	ω_i
Height	.769	.552	-	-	-	-	.276	.167
Arm span	.712	.611	-	.000	-	-	-	.348
Length of forearm	.661	.711	-	-	-	-	-	.241
Length of lower leg	.675	.541	-	-	-	-	-	.502
Sitting height	.742	.136 [a]	-	-	-	-	.276	.596
Weight	.752	-	.580	-	-	-	-	.313
Bi-iliac diameter	.661	-	.355	-	-	-	-	.661
Bi-trochanteric "	.738	-	.416	-	-	-	-	.531
Chest girth	.500	-	.625	-	-	-	-	.599
Chest width	.603	-	.523	-	-	-	-	.602
Chest depth	.429	-	.401	-	-	-	-	.809
Shoulder width	.699	-	.196 [a]	-	-	-	-	.688
Head length	.439	-	-	-	.000	-	-	.898
Head width	.286	-	-	-	-	.497	-	.819
Head height	.470	-	-	-	.000	.497	-	.729
Hand squeeze	.544	-	-	-	-	-	-	.839
Lung capacity	.629	-	-	-	-	-	-	.777
Total variance	6.554	1.495	1.499	.000	.000	.494	.152	6.798
Per cent variance	38.6	8.8	8.8	.0	.0	2.9	.9	40.0

[a] Insignificant.

TABLE 5

FACTOR LOADINGS FROM THE CORRELATIONS BETWEEN SEVENTEEN PHYSICAL MEASUREMENTS OF 305 FIFTEEN-YEAR-OLD GIRLS

Variables	α	β	γ	D_1	D_2	D_3	D_4	ω_i
Height	.691	.614	-	-	-	-	.354	.142
Arm span	.591	.740	-	.251	-	-	-	.200
Length of forearm	.581	.704	-	-	-	-	-	.409
Length of lower leg	.598	.652	-	-	-	-	-	.466
Sitting height	.674	.116 [a]	-	-	-	-	.354	.638
Weight	.694	-	.623	-	-	-	-	.361
Bi-iliac diameter	.551	-	.339	-	-	-	-	.762
Bi-trochanteric "	.611	-	.560	-	-	-	-	.559
Chest girth	.562	-	.453	-	-	-	-	.692
Chest width	.596	-	.473	-	-	-	-	.649
Chest depth	.407	-	.362	-	-	-	-	.838
Shoulder width	.579	-	.089 [a]	.500	-	-	-	.638
Head length	.330	-	-	-	.327	-	-	.886
Head width	.383	-	-	-	-	.292	-	.876
Head height	.297	-	-	-	.327	.292	-	.848
Hand squeeze	.496	-	-	-	-	-	-	.868
Lung capacity	.695	-	-	-	-	-	-	.719
Total variance	5.380	1.859	1.385	.313	.214	.171	.251	7.427
Per cent variance	31.6	10.9	8.1	1.8	1.3	1.0	1.5	43.7

[a] Insignificant.

TABLE 6

FACTOR LOADINGS FROM THE CORRELATIONS BETWEEN SEVENTEEN PHYSICAL MEASUREMENTS OF 165 SEVENTEEN-YEAR-OLD GIRLS

Variables	α	β	γ	D_1	D_2	D_3	D_4	ω_i
Height	.620	.624	-	-	-	-	.365	.305
Arm span	.546	.756	-	.276	-	-	-	.233
Length of forearm	.501	.783	-	-	-	-	-	.369
Length of lower leg	.572	.713	-	-	-	-	-	.405
Sitting height	.562	.142 [a]	-	-	-	-	.365	.729
Weight	.764	-	.531	-	-	-	-	.366
Bi-iliac diameter	.466	-	.405	-	-	-	-	.787
Bi-trochanteric "	.606	-	.500	-	-	-	-	.619
Chest girth	.609	-	.283	-	-	-	-	.741
Chest width	.670	-	.446	-	-	-	-	.593
Chest depth	.355	-	.233	-	-	-	-	.906
Shoulder width	.706	-	.170 [a]	.276	-	-	-	.630
Head length	.410	-	-	-	.395	-	-	.822
Head width	.210	-	-	-	-	.000	-	.978
Head height	.238	-	-	-	.395	.000	-	.887
Hand squeeze	.322	-	-	-	-	-	-	.947
Lung capacity	.645	-	-	-	-	-	-	.764
Total variance	4.977	2.103	1.058	.152	.312	.000	.266	8.132
Per cent variance	29.3	12.4	6.2	.9	1.8	.0	1.6	47.8

[a] Insignificant.

TABLE 7

MEANS AND VARIABILITIES OF THF DISTRIBUTIONS OF RESIDUAL CORRELATIONS FOR EACH AGE GROUP

Age	Mean	Standard Deviation	.6745 S.D.	$P.E._{r=0}$
7	+.001	.044	.030	.049
9	+.003	.045	.031	.046
11	-.002	.048	.032	.044
13	+.001	.052	.035	.045
15	+.001	.056	.038	.038
17	-.001	.056	.038	.052

criterion of the insignificance of the residuals (4, p. 57), but is possibly too low a criterion, for the factor loadings are not raw correlations but are derived from them and might be expected to be subject to chance errors greater than those of corresponding raw correlations. The factor patterns given in Tables 1 to 6 appear to reproduce the tables of correlation with a degree of accuracy slightly greater than might be expected in view of the probable errors of the indices involved.

The permissive character of any factor analysis from the statistical point of view has been granted. In support of the scheme of factors here presented, it can be said that it fits the observed data, i.e., the tables of correlations, and that it has the advantage of reducing a large set of facts to a parsimonious description. The hypothesis of a general factor plus two independent group factors seems to present a neater and more parsimonious and interpretable picture of the observed data than do the factor systems derived from similar sets of data by workers (2, 5, 6, 7) who have used the multiple-factor methods and who present overlapping group factors each of which has significant weightings in such a variety of measurements as to make its interpretation very difficult.

Wright analyzed the intercorrelations of various skeletal measurements of several populations of rabbits and fowl by still another statistical technique, that of path coefficients. He found that the influence of the general size factor predominates, but that the residuals indicated the existence of group factors for the head, the forelimbs and hind limbs collectively, the hind limbs separately, and for the wings in fowl (10, p. 619).

THE CONSISTENCY OF THE FACTOR PATTERNS

The general factor loadings of the linear variables are on the whole higher than those for the cross-sectional measurements at all ages except seventeen. In other words the linear measurements are more highly correlated with the general factor at the early ages, and especially at age eleven, but the trend begins to reverse at this point, and by the age of seventeen the cross-sectional measures correlate more highly with the general factor. If it is assumed that this general factor is a mathematical statement of some underlying genetic or environmental cause (or causes operating as a unit), which determines the general size of the various parts, it apparently operates differently after the age of eleven than before it.

This change in the factor loadings from one age to another raises pertinent questions which the data at hand cannot answer. Are the factors indicated in one pattern the same as those indicated in another? Are the factors unitary or compound? Do the underlying factors determining growth change from age to age, or are the factors really the same, but our measurements of these factors obscured in varying degrees at varying ages, by the fact that two or more factors are operating in the same direction at one period but not at another, or by other difficulties?

The fact that the factors are as much alike as they are from one age group to another (that the same group factors emerge in each pattern and that the loadings are as consistent as they are) is some indication that there are real underlying factors of which our statistically determined factors are at least useful approximations, and that these underlying factors are constant. The problems arising in the task of estimating the size factors will throw additional light on this question of the consistency of the factors.

THE GROWTH OF THE FACTORS

As a basis for the calculation of the regression equations from which the factors might be estimated for individuals or groups of persons, three composite variables were set up, all the measurements which correlate with the factor β being combined into a composite variable B, all those which correlate with the factor γ being combined into a composite variable C, and the remaining five measurements into a composite variable D. The general factor and the group factor β were then computed from a seven-rowed correlational matrix consisting of the five variables of the β group in their original form and the composite variables C and D, while the group factor γ was computed from a 9-rowed correlational matrix consisting of the seven variables of the γ group in their original form and the composite variables B and D. Harman (3) has shown that there is small loss of reliability in such a procedure.

Each factor pattern, of course, gives a different equation of estimate, applicable directly only to the age group from which it was obtained. If any growth of factors is to be traced it is necessary to select one equation and apply it to girls of all age groups.

The equations are first determined in a form applicable to the standard scores in the various measures. In the process of reducing them to a form applicable to raw scores in the original measurements, the standard deviation of the measurements is used. Since the equation finally selected was to be applied not to any one age group but to all, new coefficients of standard deviation were calculated for each measurement by throwing the distributions for all age groups together and computing the standard deviation of the distribution of each measurement among the entire population studied.

The six equations for each factor were applied first to sample groups of girls of certain age groups to determine the correlation between estimates made by the different equations, and then to the average of each age group to determine whether they revealed similar trends of growth of the factors.

Estimates of α by three different equations gave correlations ranging

from .91 to .99+ for various age groups, and the growth curves were so similar as to indicate that it made little difference which equation was used.

The estimates of the group factors, as might be expected, appear to be considerably less stable than those of the general factor. The six different equations for the estimation of β are similar in some respects but the differences in the weightings of the measures within the β group are noticeable. Estimates for a sample of 34 girls of the nine-year-old group by two of these equations gave a correlation of .748 $\pm$ .048. It is therefore much less certain whether it is justifiable to use any one of the six equations for estimates of β at all ages. However, if any growth is to be traced, some equation must be selected.

The mean values of the estimates of β for each age group as calculated by each of the six equations are shown in Table 8 and graphically in Figure 1, together with the average of the estimates at each age.

Estimates of β based on the equation for the eleven-year-old group show the greatest deviation from the typical form of the curves of mean estimate. The equation for $\bar{\beta}_9$ gives results most closely agreeing with the average trend, and has a higher reliability (R = .906) than has the equation for $\bar{\beta}_7$ (R = .782) which gives results almost equally close to the average trend. $\bar{\beta}_9$ will therefore be used hereafter in this report for estimating the factor for individuals or groups. It must be admitted, however, that the differences between the different regression equations for β, the lack of high correlation between the estimates by two of them, and the differences in these growth curves all throw doubt on the advisability of attempting to use one equation of estimate at all ages.

The regression equations for the estimation of γ show even less reliability than those of β, as measured by the multiple correlation coefficients of the regression equations. The correlation between estimates of γ by the equations for $\bar{\gamma}_9$ and for $\bar{\gamma}_{15}$ for a sample of 34 girls of age nine is, however, practically the same, .758 $\pm$ .048, as the corresponding correlation for β estimates.

The mean value of the estimates of γ for each age group as calculated by each of the six equations is shown in Table 9 and in Figure 2, where the average value of the six estimates at each age is also shown for comparison.

The curve produced by the use of the equation for $\bar{\gamma}_{11}$ deviates most widely from the typical form of these curves. The other five are fairly similar in shape. The equation for $\bar{\gamma}_{15}$ most closely approximates the average curve of growth for these estimates of the factor γ, and has been selected for future use in estimating the factor.

TABLE 8
MEAN ESTIMATES OF β FOR EACH AGE GROUP,
ACCORDING TO SIX DIFFERENT EQUATIONS

Age	$\bar{\beta}_7$	$\bar{\beta}_9$	$\bar{\beta}_{11}$	$\bar{\beta}_{13}$	$\bar{\beta}_{15}$	$\bar{\beta}_{17}$	Average
7	20.00	20.00	20.00	20.00	20.00	20.00	20.00
9	21.50	21.01	21.20	21.06	21.43	21.59	21.30
11	22.54	21.61	21.65	21.69	22.54	22.89	22.15
13	23.16	22.20	21.62	22.06	23.40	23.80	22.71
15	22.87	22.06	20.97	21.79	23.33	23.80	22.47
17	22.65	21.91	20.65	21.64	23.14	23.58	22.26

TABLE 9

MEAN ESTIMATES OF γ FOR EACH AGE GROUP, ACCORDING TO SIX DIFFERENT EQUATIONS

Age	$\bar{\gamma}_7$	$\bar{\gamma}_9$	$\bar{\gamma}_{11}$	$\bar{\gamma}_{13}$	$\bar{\gamma}_{15}$	$\bar{\gamma}_{17}$	Average
7	20.00	20.00	20.00	20.00	20.00	20.00	20.00
9	20.22	20.10	19.66	20.22	20.11	19.96	20.04
11	20.93	20.58	19.57	20.79	20.57	20.33	20.46
13	22.06	21.56	20.47	21.84	21.65	21.33	21.48
15	22.91	22.20	21.12	22.35	22.13	21.77	22.08
17	22.97	22.54	21.52	22.33	22.12	21.74	22.20

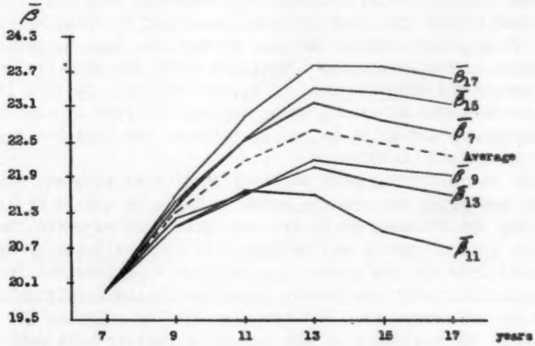

Fig. 1. Mean estimates of β for each age level according to six different regression equations.

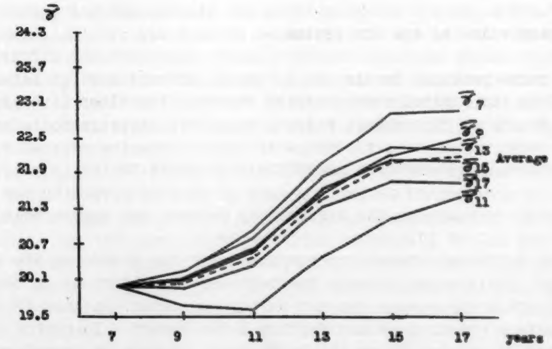

Fig. 2. Mean estimates of γ for each age level according to six different regression equations.

A comparison of the curves of Figure 1 with those for Figure 2 indicates typical differences between the form of the growth curves for the two group factors. The factor β shows rapid growth from the age of seven to that of eleven with a leveling off or decrease at thirteen. The γ factor characteristically shows very little growth from seven to nine, slight increases from nine to eleven, rapid growth from eleven to fifteen, with a leveling off at fifteen.

GROWTH OF THE FACTORS IN RELATION TO THE ADVENT OF THE MENARCHE

Since the advent of the menarche has been frequently shown to be closely associated with changes in the rate of physical growth, the girls of the present study, for whom the necessary data were available, have been subdivided into four sections according to their age at the menarche. Mean growth curves for each factor have been worked out for each maturity section. Section I includes girls for whom the menarche appeared during the eleventh year of age or earlier; Section II, girls for whom the menarche appeared during the twelfth year of age; Section III, thirteenth; and Section IV, girls for whom the menarche appeared after the fourteenth birthday.

The mean estimates for each maturity section at each age for both the general and group factors are shown in Table 10 and in Figures 3, 4, and 5. Since the evidence which has been presented suggests that estimates of the general factor may be made with high reliability by equations derived from any age group, the equation $\bar{\alpha}_{9b}$ (derived for the nine-year-old girls with the linear variables in their original form and the others in two composites) has been arbitrarily selected for the estimation of α. The estimates of the two group factors have been made by equations $\bar{\beta}_9$ and $\bar{\gamma}_{15}$, but as has been noted the estimates of the group factors have low multiple correlations and the results obtained here for the group factors must be considered as suggestive only.

The growth curves for the general factor present a consistent pattern. The earliest maturing section exceeds the other three at age seven, noticeably increases its superiority at age eleven, and has largely lost its advantage by the age of fifteen.

The two middle sections have noticeably decreased the differences between themselves and Section I at age 13, but the section latest in maturing is still considerably behind the other sections at that age.

The growth of the general factor, therefore, appears to be definitely and positively related to the stage of sexual maturity reached by the girls. The mean growth of a section of the girls in the general factor seems to be accelerated during the year of or just preceding the menarche, and retarded thereafter, the differences between the groups being negligible at the age of 17.

A very different picture is presented for the growth of the group factor β. Differences between the sections are slight up to the age of 11. Thereafter the curves fan out in inverse order, Section IV having consistently highest place and Section I the lowest. In noting this superiority of Section IV at the later ages, it must be remembered that high estimates of β might be obtained from the use of the regression equation through large mean values of the height and limb measures which

TABLE 10

MEAN ESTIMATES OF THREE FACTORS IN THE PHYSICAL MEASUREMENTS OF GIRLS OF VARIOUS MATURITY SECTIONS

Age	Mean Estimates for All Girls in This Study	Mean Estimates for			
		Section I (Menarche during 11th Year or Earlier)	Section II (Menarche during 12th Year)	Section III (Menarche during 13th Year)	Section IV (Menarche during 14th Year or Later)
		General Factor, $\bar{\alpha}_{9b}$			
7	20.00	20.40	19.36	19.27	19.25
9	22.44	22.90	22.39	21.92	21.78
11	24.99	26.59	24.93	24.46	23.64
13	27.39	27.99	27.74	27.14	25.96
15	28.57	28.55	28.78	28.52	28.35
17	28.92	28.90	28.90	29.04	28.80
		Group Factor, $\bar{\beta}_9$			
7	20.00	20.42	20.42	20.56	20.22
9	21.01	21.16	21.01	21.21	20.84
11	21.61	21.62	21.79	21.01	21.50
13	22.20	21.65	22.22	22.53	22.63
15	22.06	21.27	21.35	22.31	22.65
17	21.91	21.06	21.63	22.04	22.80
		Group Factor, $\bar{\gamma}_{15}$			
7	20.00	20.22	20.07	20.62	20.11
9	20.11	21.14	19.95	20.12	20.14
11	20.57	21.72	20.32	19.98	20.58
13	21.65	23.03	22.10	21.30	21.09
15	22.13	22.97	22.17	21.99	21.65
17	22.12	22.81	22.33	22.21	21.81

enter positively into the equation, or through low mean values of the weight and cross-sectional and other measures which enter negatively into the equation, or through both. A study of the means of the sections in the original measurements showed, for these groups as for similar ones studied by Shuttleworth (9), that the later maturing girls do not attain superiority over the early maturing girls until the age of seventeen in the linear measures, but that they consistently lag behind in the cross-sectional measures from 11 to 17. The estimates of β are, therefore, not so much indicative of linear growth itself, as of a linear type of body, i.e., high mean estimates of β are characteristic of a group of girls who tend to have lighter weight and smaller cross-sectional measurements for the same height and limb lengths.

Interpreting $\bar{\beta}$, then, as a measure of linearity of type, Figure 4 indicates that between the ages of 7 and 11 the girls of all four sections are stretching up, becoming more linear in type, and without significant differences between the sections. With puberty this tendency is checked, the filling out process becomes relatively more important and the mean estimates for the sections indicate a decrease in linearity. This is true for Section I after 11, these girls having reached puberty

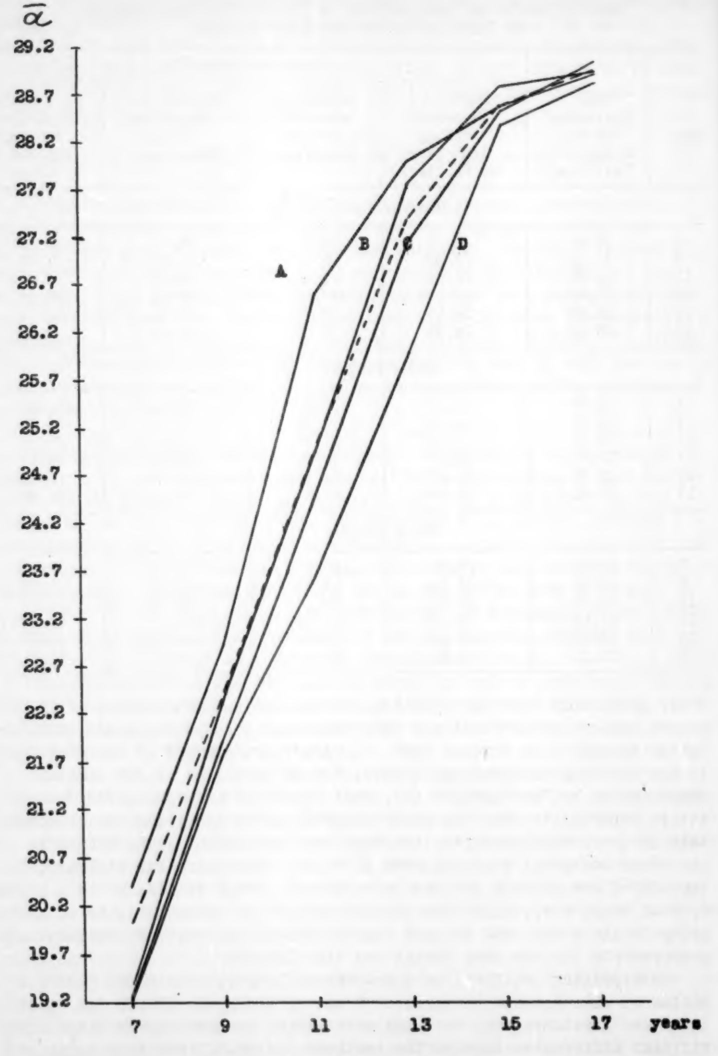

Fig. 3. Comparison of the mean growth of the general factor for four maturity sections and for all subjects (according to the equation for $\bar{\alpha}_{9b}$).

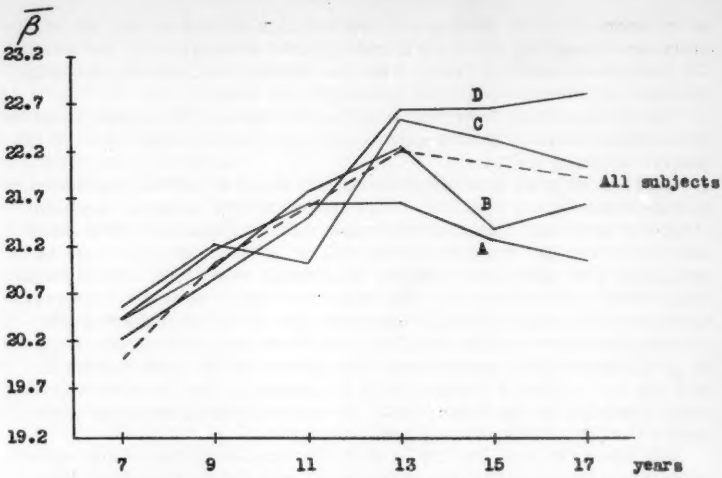

Fig. 4. Comparison of the mean growth of the group factor β for four maturity sections and for all subjects.

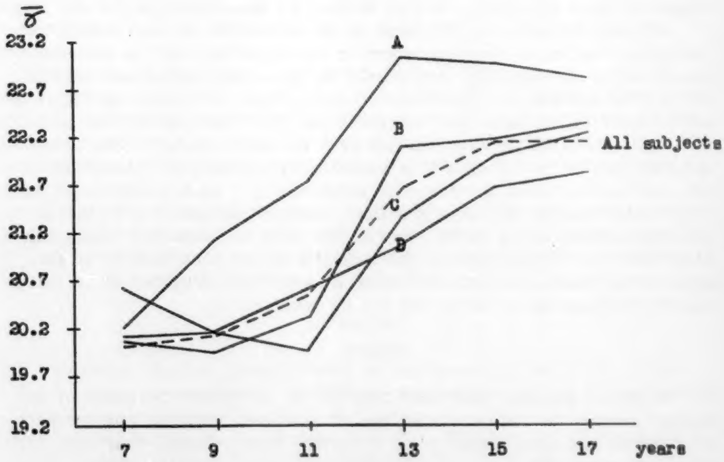

Fig. 5. Comparison of the growth of the group factor γ for four maturity sections and for all subjects.

at or before 11. For Sections II and III this is true at age 13, at which age or earlier these girls had attained puberty. Only for Section IV, the latest maturing group, does the tendency to linearity not only persist but increase up to the limits of this study.

The girls of the latest maturing section appear, therefore, to be on the average permanently of a more linear type than are the girls of the earlier maturing sections.

These deductions from the β curves are verified by the complementary picture shown in the γ curves. High estimates of γ would be produced either by high mean values of the cross-sectional measures which enter positively into the regression equation, or by low mean values of the height and limb and other measures which enter negatively into the equation, or by both conditions. The relative weightings of the different measures in the two regression equations are of course different and some measures enter negatively into both equations, so that the factor is by no means merely a measure of the obverse of β. The factors in fact are by hypothesis statistically independent. The factor γ is, however, a measure of the relationship of cross-sectional measures to height, rather than of cross-sectional measures alone.

The three sections II, III, and IV, all appear to follow a γ -growth curve similar to that for the whole group, showing little change from 7 to 11 with rapid increase in the prepubertal years and a retardation in the rate of increase thereafter. The girls who reach puberty earliest, however, show a very different trend of growth in this factor, with rapid increase in γ all the way from 7 to 13, during both prepubertal and one or more postpubertal years, and maintain a wide superiority over the other sections in respect to this factor, at least through the age of 17.

If the γ factor is interpreted as an expression of some underlying influence tending to accelerate growth in weight and the hip and chest measurements more rapidly than growth in the other dimensions, in other words of a tendency to stockiness of build, then the curves of Figure 5 may be said to indicate that the girls who will reach puberty at an early age show this tendency from the age of 7 on, while girls of the later maturing groups do not show this tendency till after 11. The girls of the earliest maturing section show persistently a much higher index in this trait than do the other sections, through the age of 17. For girls who will not mature so early, this factor does not come into operation till after 11. Thereafter it produces its effect most rapidly in the prepubertal years, the rate of change in body type produced by it being sharply decelerated at about the age of puberty.

SUMMARY

Factorial analyses have been made by the bi-factor technique of six tables showing the intercorrelations of seventeen physical measurements of girls of the ages respectively of seven, nine, eleven, thirteen, fifteen, and seventeen.

At all age levels studied a general size factor may be postulated which accounts for from thirty to fifty per cent of the total variance of the seventeen measurements.

The general factor as derived from the correlation matrices for the

various age groups is fairly consistent although at the earlier ages the linear measures correlate more highly with it and at the later ages the cross-sectional measures have higher loadings. The differences are not so great, however, but that the estimates of the general factor based on the six different factor patterns present very similar mean growth curves for the whole group, and that estimates made by one correlate highly with estimates made by another.

At all age levels studied, two group factors are apparent after the effect of the general factor is removed. One of these is found in the residual correlations of height, span of arms, length of forearm, and length of lower leg. Sitting height proved not to be significantly correlated with this factor. The proportion of the variance ascribable to this factor varies from 3.6 per cent at age 7 to 12.4 per cent at age 17. Estimates of this factor by regression equations calculated from different factor patterns do not correlate as highly with each other and do not give as similar growth curves as do the various estimates of the general factor.

The other group factor γ is found in the residual correlations for weight, bi-iliac and bi-trochanteric diameter, and chest girth, width, and depth. Shoulder width was the only cross-sectional trunk measure which did not have significant correlations with this factor at all ages, and it does have at ages 9 and 11. Factor loadings and regression weights for this factor also are not consistent from age to age. Its contribution to the total variance varies from 6 per cent for the seventeen-year-old group to 11.8 per cent at age 9.

The present data indicate that these two factors do exist at all ages, but it is probable that the measures used do not give sufficiently pure estimates of the group factors to make their prediction of much value at the present time.

Estimates of the general and group factors for girls of different maturity sections indicate that the general factor is closely related to the stage of sexual maturation. Growth curves for the estimates of the general factor show rapid growth in the years just preceding puberty and deceleration thereafter, with no permanent superiority for the early maturing group.

The group factors appear to be indicators of body type, the β factor giving crude measures of some underlying factor tending toward linearity of body type and the γ factor giving crude measures of some underlying factor tending toward stockiness of body type.

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AN ANALYSIS OF THE VARIANCE OF CONFLICT BEHAVIOR IN PRESCHOOL CHILDREN[1]

MERRILL ROFF AND LOUISE ROFF[2]

Most studies of the behavior of children in preschool age have been made with groups in university nursery schools, who come from families that are an extremely selected sample of the total population. With the development of W.P.A. nursery schools it has become possible to observe children who have backgrounds markedly different from those of children whose parents are in the professional or upper business groups. If we compare with university nursery school children the W.P.A. school populations in the "steel area" of South Chicago, for example, or in a negro area in East Chicago, or in a southern Indiana town, ordinary observation suggests that there are important differences in the behavior of the children from these various groups. On the other hand, we have found in the literature few specific hypotheses concerning such differences.

In most cases, investigations of children's behavior have treated the group studied simply as a more or less random sample of the whole population of children, and have tried to explain differences in behavior, as far as possible, by reference to a few simple, general, and abstract psychological concepts such as age, sex, level of intelligence, etc., which would operate more or less uniformly through the whole population. It seemed obvious that the groups mentioned above were not random samples of a general population, but were markedly selected and of interest because of this diversity. Some of the factors operative in the selection of children in these groups are easily apparent, for example, proximity to the nursery school and economic level. There are other factors of selection which are not so apparent, such as interest of the parents in the welfare of the child, experience or acquaintance with nursery schools, occupation and duties of the mother, and so forth.

If we should observe all the existing groups of nursery school children, we would find similarities in behavior which would cut across differences in background and setting. It would be possible to find groups of children who were so diverse in intelligence that the groups would not overlap at all, but they could all be placed on the same intelligence scale. It would probably be possible to find groups who would differ as much in other psychological or personality characteristics, but this region is almost completely uncharted. Many workers in the field of intellectual abilities and language have made rough divisions according to socio-economic status and studied differences in performance related to these groupings. A few studies, i.e., Francis and Fillmore (6) and Springer (21), have reported differences in general personality adjustment in school age children from widely different economic levels. Gesell and Lord (7) gave tests and ratings on certain personality characteristics to eleven pairs of children; one member of each pair was from a superior economic group and one from a low economic group. Goodenough (9

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and 10) has also noted differences in shyness, negativism, and distractibility during mental tests which were associated with economic level of the parents. Jersild and Markey (14) and Dawe (4) have reported differences in amount of conflict behavior shown by children of upper and lower economic groups. On the whole, however, the incidence of certain behavior characteristics in different groups of children has been attacked only in a very general manner or has been a matter of incidental observation in studies primarily concerned with other questions.

The term "socio-economic" is, in practice, usually employed as if it meant merely "economic," due to the ease of differentiation on the basis of income. It is a relatively simple task to classify families on the basis of their economic or occupational status, but to give a description of the "socio-" and psychological factors associated with such differences which might be expected to influence (for example) the emotional development of the children involved is a much more difficult problem. A related classification of the factors which influence child behavior, which is receiving increasing emphasis, is that into cultural and non-cultural. Specific reference to cultural influence is made by Murphy (20) in her study of sympathy behavior, in which "cultural" is a general term opposed to "constitutional," as one of the two main factors in behavior. Undoubtedly some of the influences on children's behavior would be called "cultural" with almost any definition of the term, but it is also true that many of these non-constitutional influences would be considered non-cultural by any definition less broad than that of Lowie (18), who defines culture as equivalent to all acquired behavior and then defines psychology as the study of the "inborn attitudes and behavior of human beings." A more restricted definition of culture, which is representative of a somewhat different point of view, is that given by Linton: "A culture as distinct from culture in general, may be defined as the sum total of the behavior patterns, attitudes and values shared and transmitted by the members of a given society" (17, p. 425). This definition permits the development of a conceptual framework which seems more promising for psychological problems than a constitutional-cultural dichotomy. As Linton points out: "Seen from his own point of view, the setting of the individual consists not of abstract culture patterns but of concrete things and people. . . The actual behavior of a father toward his son will be a function not only of the culture patterns but also of the father's temperament and of the attitudes between father and son which have been developed through previous experience. Thus the pattern may require that the father punish his son for a certain offense in a certain way, but whether the punishment is as light as possible or as heavy as possible, administered with regret or obvious enjoyment, will depend on non-cultural factors" (17, p. 436). Anyone interested in a thorough treatment of this problem may be referred to J. R. Kantor's An Outline of Social Psychology (15).

We know, in a general way, that both "cultural patterns" running through a "total culture" and differences in customs and attitudes which are peculiar to certain groups of a population or even to particular families are important determinants of the child's social behavior as they influence, or are reflected in, the behavior of the parents or other persons toward the child. Our knowledge of how these factors influence specific types of behavior is very limited. What is needed is

a method of analysis more concrete and more flexible than those which have been used in previous studies, which will bring out differences between specific groups in various kinds of psychological activities. The different groups of adults who are parents of children in specific nursery schools will vary from each other and from other adult groups in the population in certain known ways. For instance, they will vary as groups in level of intellectual ability, in amount of formal education, in health, in types of recreation enjoyed, in stability of living conditions, and in doctrines of child training, to name but a few variables. What implications these or other differences among subgroups of the population may have for the development of specific types of behavior in the children of these adults have not yet been determined.

The group of children which was most available to us for continued observation was one in a W.P.A. nursery school in Bloomington, Indiana. In informal observation, the children as a group seemed to show less attention-getting behavior, less resistance to the suggestions of the teachers, more willingness to share materials and to include others in play, and smaller amount of talking than the children we had seen in university nursery schools. We selected for systematic study an apparent difference in conflict behavior, primarily because the careful study of conflicts by Jersild and Markey (14) had established a procedure which could be duplicated, and because their observations covered three different nursery schools with which our group could be compared. We also made a smaller number of systematic observations in a W.P.A. nursery school in Chicago.

Jersild and Markey describe the groups in which they studied conflict behavior as follows (14, p. 6):

> Group A. Seventeen children, including eleven boys and six girls, with an average age of 29.1 months and an age range of 22 to 36 months at the mid-point of the observations, members of a nursery school associated with the Child Development Institute of Teachers College.
>
> Group B. Nineteen children, including thirteen boys and six girls, with an average age of 42.7 months and an age range of 33 to 50 months at the mid-point of the observations, members of the Guidance Nursery group at the Child Development Institute.
>
> Group C. Eighteen children, including six boys and twelve girls, with an average age of 38.3 months and an age range of 26 to 48 months at the mid-point of the observations, members of the nursery school group of Manhattanville Day Nursery.

They made a continuous record of the behavior of each of the fifty-four children for ten fifteen-minute periods, of which eight periods were taken out-of-doors and the remaining two indoors. For fifty of the children the observations were spread over a period of three to five months. "The aim was to record all activities that might be construed as belligerent, defensive, offensive, resistant, or provocative under the most liberal interpretation of these terms" (p. 10). "Each act that constitutes an initial act of aggression in a sequence of interchanges, or in

an unretaliated attack by one child upon another . . . marks the beginning of a new conflict" (p. 29). Each child would also appear in the records when he was not the object of direct observation, if he came into conflict with a child who was being observed. These conflicts were totaled under the heading "indirect observations." There was an agreement of 97 per cent between different observers on the total number of conflicts; reliability coefficients of .87 and .90 were obtained with two different arrangements of the total values for direct and indirect observations.

When the three different nursery school groups were compared, Jersild and Markey found marked differences in the frequency of conflicts. In Table 1 the average number of conflicts per child is given for all the groups combined and for each group separately. It is clear from this table that there are marked differences in conflict frequency between the three groups with the older nursery school group connected with the Child Development Institute showing the least conflicts and the day nursery group the most. Jersild and Markey point out that their results "indicate that the character of the group, quite apart from the factor of age, may have a telling effect on the trend of the findings. The general conclusions emerging from the present study would be quite different on many points had the study been confined to groups similar to Groups A and B" (pp. 85, 86). From their analysis of the differences in the make-up of the populations of these three groups and the general characteristics of the nursery schools, they come to the conclusions that the following factors "may (with varying degrees of assurance) be regarded as contributing to the higher frequency of conflicts in Group C as compared with Groups A and B: 1) socio-economic status; 2) intelligence; 3) amount of play space and equipment; 4) amount of teacher interference and number of teachers in attendance; 5) relative frequency of teacher interference with the children; 6) national background" (p. 99). The authors believe that the "role played by teachers is one of the most important factors, but a final statement as to how significant each of the various factors is, or a final estimate of the weight of each factor cannot be given" (p. 99). Further consideration of the differences between these groups, and possible factors related to frequency of conflicts will be given in connection with the results from our observations.

PROCEDURE

The group for which we have a complete set of observations consisted

TABLE 1

AVERAGE NUMBER OF CONFLICTS PER CHILD DURING TEN FIFTEEN-MINUTE PERIODS AS GIVEN BY JERSILD AND MARKEY

	All Groups Combined	Group A	Group B	Group C
Direct observations	30.9	30.2	16.0	38.1
Indirect observations	30.8			
Total direct and indirect observations	58.0	62.1	34.3	80.7

of seventeen children, including nine boys and eight girls, with an average age of 39.1 months, an age range of 20 to 50 months (S.D. 6.4 months) at the mid-point of the observations, members of the W.P.A. nursery school in Bloomington, Indiana. All the parents of both sexes were native Americans, and most of them came from families which had lived in southern Indiana for several generations. There is considerable interrelationship and shifting back and forth of the people in town and of the people engaged in farming in the surrounding country. The neighborhood from which the children come is a "working class" neighborhood made up of individual houses. One of the main industries of the county is quarrying and milling limestone. Five of the fathers worked at one kind of stone cutting or another, when work was available. (The limestone industry has been somewhat depressed for a number of years.) The rest of the fathers gave their occupations as follows: grocery clerk, clerk in bakery, laborer, W.P.A. painter, round-house worker for a railroad, and one deceased father had been a railroad ticket agent. The mothers were primarily housewives, although some of them worked occasionally as clerks in stores or did domestic work, and one had occasionally taught as a substitute in grade school. No one of them was employed steadily outside the home. The actual monthly income for the families was not known exactly, but was in most, if not all, cases less than $90 a month. The average number of years of formal education for the fathers was 9.8, with a range from 8 to 13, and for the mothers was 11.9, with a range from 8 to 14 (one mother had had two years of college work). The average number of children per family was 3.2 with a range from 1 to 7. There was but one only child. The average birth order for these children was 2.6.

For the variables amount of income, type of occupation, amount of formal education, and size of family, the families from which these children come are probably representative of a rather large segment of the population of the country, though differing markedly from the families from which most university nursery school groups draw their members.

Stanford-Binet tests were given to twelve of the seventeen children. The average I.Q. for these twelve was 107, with a range from 89 to 125. More than half the children fell between 100 and 110. Three, two of them siblings, had I.Q.'s in the 120's.

The nursery school itself was adequately equipped, though definitely less well provided with play equipment than a university nursery school. There were three medium-sized rooms for inside activities, and a small playground for outdoor play. There were two teachers connected with the school, and both were present during nearly all of the observations.

We followed the observational procedure of Jersild and Markey as closely as we could. "Each child .....was observed during ten distributed 15-minute periods.....The observer followed one child at a time and recorded, as fully as possible, the behavior of this child in his contacts with other children as well as the behavior exhibited by other children in their contacts with him. The record was taken in the form of a running, diary account....." (p. 152). Our records were made in short-hand but were otherwise similar. Observations were made during the free play period in the forenoon. More than half the observations, however, had to be taken inside, as bad weather conditions and clothing which was

inadequate for extended periods of outdoor play, in the case of a few of the children, prevented outdoor play most of the time during the first two months of observation. Since conflicts were more frequent indoors than out, this results, probably, in increasing our total conflict frequencies as compared to those of Jersild and Markey's groups.

In the analysis of our records we followed the method of Jersild and Markey, and took their definition of conflict; "For the purpose of this study, a conflict is defined as any instance in which one child attacks another's person or by word or deed interferes with the person, activities, or possessions of another, or threatens by word or gesture to do so, or endeavors by force or verbal demands to possess another's belongings, or direct another's activities in opposition to the apparent desires of the child against whom the aggression is made . . . Contacts that involved seemingly accidental bumps and collisions, or apparently playful interchanges of hits and pushes were not treated as conflicts" (pp. 152, 153).

For our group we obtained the following results:

	Average frequency of conflicts	Range	Sigma
Direct observations	15.4	3-34	8.2
Indirect observations	15.5	1-39	
Total direct and indirect combined	30.8	8-61	16.2

The average number of conflicts in direct observation is approximately half that of the average (30.9) of Jersild and Markey's three groups combined, and that of the total (direct plus indirect) is slightly more than half their value (58.0). The mean and the standard deviation fall near those of Jersild and Markey's B group. If we had had the same proportion of observations outdoors as they had, the mean probably would have been one or two units lower, since we found more conflicts in the observations taken inside. (Dawe (4) and Caille (3) also found a tendency for more quarreling and resistance indoors.) We are using the obtained mean without correction in order to avoid any over-accentuation of differences between the groups.

We have an incomplete set of observations from a W.P.A. nursery school in Chicago, which were obtained in the summer of 1938. Since we were able to complete only three observations for most of the children these results are not included in the analysis of variance made later on. However, though the figures obtained for individuals are not very reliable because of the small number of observations, the totals for the group as a whole are consistent enough to warrant a brief summary of the results obtained. With the Bloomington group it was found that the average number of conflicts per observation was 1.4 for the first three observations for each child, and 1.5 for the last three observations for each child, as compared with an average of 1.5 for the total ten observations. For the Chicago group, the average per observation was 2.3 for the combined scores of the first and last observations for each child; 1.8 for the second observation for each child, and 2.1 for the total observations. These figures would seem to indicate that on the basis of as few as three observations per child the group as a whole can be fairly accurately ranked in comparison with other groups on the basis of total

number of conflicts.

This group consisted of sixteen children, nine boys and seven girls, with an average age of 41 months, and an age range of 32 to 51 months, with a sigma of 5.2, at the mid-point of the observations. Five of the fathers were of foreign birth (2 Italian, 1 German, 1 Norwegian, 1 Scottish) and four of the mothers (3 Irish, and 1 Canadian). As far as possible the national grouping of the rest of the parents, who were American born, was determined. Including both the children with foreign-born parents and those whose parents were of foreign extraction, there were five children with Italian ancestry, four who were partly of Irish extraction, one with part German, one with part Scottish, one with part Canadian, and one with part Norwegian ancestry. On the whole, with the exception of the five children of Italian extraction, the group was made up of children of North European extraction. The neighborhood was a relatively stable one, made up largely of single or double houses. Two of the fathers were on W.P.A.; two were unemployed; one was a grocery clerk; one, a bartender; one worked in a bakery; one, as a clerk in a railroad office; two were factory workers; one was a truck driver; one, a bill poster; and one was a small storekeeper. Six of the mothers worked outside the home part of the time. In the case of twelve of the children the average monthly income of the family was known. It ranged from $47 (for one family on relief) to $120 a month, with an average monthly income for the group of $82 a month. The average number of years of formal education for the fathers was 9.3 years, with a range from 6 to 12, and for the mothers, 9.7, with a range from 6 to 14 (one mother had two years of business college). The average number of children per family was 2.6, with a range from 1 to 6. There were five only children, and five with only one living sibling. The mean birth order for the sixteen children was 2.3.

Stanford-Binet tests were given to nine of the children. The average I.Q. was 114 with a range from 88 to 140; three of the children had I.Q.'s above 120, and only one fell below 100.

The nursery school was located in a settlement house and received some support from it. There were three teachers altogether, and at least two of them were present during nearly all the observations. The observations were all taken during the outdoor free play period. The playground was large, more than twice the size of that of the Bloomington nursery school. The play equipment was more than adequate, definitely better than that for the Bloomington group and not much below the average of the university nursery schools which we have seen.

The observational procedure was the same as for the other group except that all the observations occurred in the outdoor play period, and only three observations were obtained for most of the children.

The results given in the table below were obtained by multiplying the observed conflict frequency of each child to obtain the estimated frequency if he had been observed for ten periods, so that the results would be directly comparable with those of the other groups.

	Average frequency of conflicts	Range	Sigma
Direct observations	21	7-43	10.5
Indirect observations	24	7-57	
Total direct and indirect	45	17-100	18.8

In order to facilitate comparisons between the different groups three tables are given below. Table 2 gives a summary of the frequency of conflicts in each of Jersild and Markey's three groups and in our two. Table 3 gives a summary of the average number of conflicts per observation for direct observations according to six-month-age levels. The lowest age levels were omitted because there were too few children observed at these ages to afford satisfactory comparison. Table 3 not only indicates no consistent trend in frequency of conflict with age, but also shows that the different nursery schools maintain their relative ranking fairly consistently at different age levels. Jersild and Markey obtained rank-difference correlations between age and number of conflicts of 0.02 in group A, 0.14 in group B, and -0.34 in group C. Other studies have noted some age differences. Green (12) found the most quarreling at three years and Caille (3) found that resistant behavior was most frequent at the three-year level. Dawe (4) on the other hand, found that quarreling decreased with age.

Jersild and Markey investigated also the relationship between number of conflicts and intelligence ratings, and obtained the following correlations:

Test	Group A	Group B	Group C
Minnesota Preschool	-.45	.00	-
Kuhlmann-Binet	-.50	-.02	-
Merrill-Palmer	-.15	-.40	-.24

Dawe (4) found a rank-order correlation between frequency of quarreling and I.Q. of -.17. In general, there seems to be a slight, though not consistent, tendency for brighter children to engage in fewer conflicts

TABLE 2

AVERAGE NUMBER OF CONFLICTS PER CHILD IN FIVE DIFFERENT NURSERY SCHOOLS

	Group A nursery school*	Group B nursery school*	Group C nursery school*	Bloomington W.P.A. nursery school	Chicago W.P.A. nursery school
Number of children	17**	19	18**	17	16
Age range in months	22-36	33-50	26-48	20-50	32-51
Average age	29.1 (4.3)	42.7 (4.8)	38.3 (7.8)	39.1 (6.4)	41 (5.2)
Conflicts in direct observations	30.2 (8.5)	16.0 (8.0)	38.1 (9.1)	15.4 (8.2)	21 (10.5)
Total conflicts direct and indirect observations	62.1 (24.8)	34.3 (15.5)	80.7 (24.1)	30.8 (16.2)	45 (18.8)

* These groups are the three groups studied by Jersild and Markey.
** In Group A and Group C one child was not counted in the indirect observations. Figures in parentheses represent sigmas.

TABLE 3

AVERAGE NUMBER OF CONFLICTS PER CHILD PER 15-MINUTE PERIOD OF OBSERVATION AT SUCCESSIVE SIX-MONTHS AGE LEVELS

This table is based on direct observations only. Ages are represented in terms of the child's age at the time a given 15-minute observation was made, and the same child may be represented at different age levels.

	Age in months			
	30-35	36-41	42-47	48-53
Group A				
Number of 15-minute observations	68	9	0	0
Average conflicts per observation	3.3	2.3		
Group B				
Number of 15-minute observations	12	72	71	35
Average conflicts per observation	1.2	1.7	1.6	1.4
Group C				
Number of 15-minute observations	52	21	72	8
Average conflicts per observation	4.2	3.5	3.3	3.8
Bloomington				
Number of 15-minute observations	44	36	36	43
Average conflicts per observation	1.1	1.0	2.1	1.7
Chicago				
Number of 15-minute observations	8	18	14	6
Average conflicts per observation	2.0	2.2	1.9	2.5

than do duller ones.

Sex differences in our groups were found to be completely negligible. In the Bloomington group the average number of conflicts (direct and indirect observations) was 30.6 for the boys and 31.1 for the girls; in the Chicago group, the average for the boys was 44.6 and for the girls 46.3. Most studies, however, have reported sex differences. Jersild and Markey found a slightly larger number of conflicts for boys than for girls in all groups, but when the children in each group were matched for age, groups A and B, with a predominance of boys, showed more conflicts among the boys, and Group C with a predominance of girls showed a larger number of conflicts for the girls. The differences were small and statistically unreliable. They interpret their findings as indicative that the sex that is in the majority exhibits the most conflict behavior and believe that this is a function of the frequency of social contacts, since children of the same sex play together more than those of opposite sexes. Our results would not disagree with this hypothesis, as our groups were almost evenly divided between the two sexes. In the studies dealing with quarreling [Green (11 and 12) and Dawe (4)] , aggressive behavior [Caille (3) and Hattwick (13)] , resistant behavior [Caille (3)] , anger [Goodenough (8)] , and negativism during mental tests [Goodenough (9 and 10) and Mayer (19)] sex differences have been found, with boys showing more of the type of behavior studied. When Goodenough (9 and 10) in her study of negativism divided the children into two groups on the basis of socio-economic level, the group comprising the upper

three economic classes showed a marked sex difference with boys exhibiting more negativistic behavior, but the group from the lower economic levels showed only a slight sex difference, and the relative standing of the two sexes was reversed, with the girls showing more negativism. Levy and Tulchin (16) also found more resistant behavior among girls during mental tests in a group of children fairly representative of rural and small town populations, but the total amount of resistant behavior observed was not very great. These findings in the field of negativism during mental tests indicate the possibility that sex differences which may occur in upper economic groups may not necessarily be of the same order in groups of lower economic status. It is possible, therefore, that our finding of no sex difference is linked with the composition of the groups we studied.

The factors which Jersild and Markey thought might be of significance in explaining the differences between their groups are 1) socio-economic status, 2) intelligence, 3) amount of play space and equipment, 4) amount of teacher interference and number of teachers in attendance, 5) relative frequency of teacher interference with the children, and 6) national background. It is evident that economic status by itself is not a significant factor, as our groups were much more similar to the day nursery group than to the others in this respect and yet were relatively low in conflicts. Dawe (4) also found a slight tendency for children from lower economic groups to quarrel less (in a group composed of children from different economic levels). Since the "socio-" status of each group cannot be adequately defined, it is difficult to evaluate its contribution. Similarly, intelligence does not appear to have any close relation to number of conflicts. Both our groups had an average intelligence level near that of Jersild and Markey's group C, but their conflict frequencies differed markedly from that of the New York day nursery group.

We found no relationship between amount of play space and equipment and number of conflicts. Our Bloomington group was rather limited in both respects, whereas the Chicago group had much more play space and more equipment yet was higher in number of conflicts. Common experience indicates that the amount of play space and amount of equipment would be factors in extreme cases. It could be predicted with considerable confidence that three children forced to play in a closet would have more conflicts in a given period of time than the same three allowed to play in a sizeable yard, and similarly, it is probable that these same children would show more conflicts if provided with only one toy to play with than if provided with a number of possible play things. On the other hand, our data in conjunction with that of Jersild and Markey's show that amount of play space and equipment are, within a considerable range of variation, relatively unimportant in comparison to other influences.

Neither the number of teachers nor the amount of teacher interference with conflicts accounts for the differences between the five groups. The Group A school had twice as many teachers and the same percentage of conflicts interfered with by teachers as the Bloomington group, and had about twice as many conflicts. The Chicago group had markedly less interference by teachers than any other group, but falls in a median position in number of conflicts. The Group B school had five teachers as compared with two in the Bloomington school, and slightly more teacher

interference in conflicts, but was not below the Bloomington group in number of conflicts. Here again, either of these factors would undoubtedly be of importance in extreme cases, but they are not very influential within the limits of these five groups. It is possible, however, that the role of the teachers in children's conflicts may not be adequately estimated merely by number of teachers and the frequency of their interference in conflicts.

We can come to no conclusion concerning the effect of nationality as both of our groups were largely of North European extraction. We found no difference in number of conflicts between the five children of South European extraction and those of North European extraction in our Chicago group. (The figures were 44.2 and 45.8, respectively, for total frequency of conflicts.)

Table 4 summarizes the chief characteristics of the three Jersild and Markey groups and our two with respect to these factors.

ANALYSIS OF VARIANCE

The above considerations indicate a need for a more concrete and specific analysis than that in terms of age, socio-economic class, or other general category. One way in which a start can be made in this direction is to analyze the variance of the conflict frequencies into inter-group and intra-group variance, using the technique developed by R. A. Fisher (5).

An implicit and somewhat tautological-sounding assumption underlying this procedure as well as other work on individual differences is that all the members of a given population would be identical were it not for influences causing them to be otherwise. A measure of difference with several statistical advantages is the variance, or square of the standard deviation, of a population. If a population is made up of several sub-populations, each with its own mean, standard deviation, and variance, the variance of the total population is the sum of two quantities, 1) the sum of the variances of each sub-population around its own mean, known as the intra-group variance, and 2) the variance of the means of the sub-populations, known as the inter-group variance. Since the total variance is a sum, the two components can each be spoken of as contributing such-and-such a percentage of the total variance. If the means of the sub-populations differ little, so that the distributions of the sub-populations would largely overlap, then a large percentage of the total variance would come from the intra-group variance; this would mean that other factors than those by which the sub-populations were divided were responsible for the differences between members of the total population. Conversely, if the means of the sub-population were well apart, and their distributions overlapped but little, a major percentage of the total variance would come from the inter-group variance; this would mean that the factors which were the basis of division into sub-populations, or other factors associated with these, were primarily responsible for the differences between members of the total population.

The discussion above of the influence of age, sex, etc., would indicate that almost all of the total variance would be due to intra-group factors, when sub-populations are formed on the basis of age, sex, etc.

TABLE 4

SUMMARY OF CHARACTERISTICS OF FIVE NURSERY SCHOOL GROUPS

	Group A nursery school	Group B nursery school	Group C nursery school	Bloomington W.P.A. nursery school	Chicago W.P.A. nursery school
No. of children	16	19	17	17	16
Av. age (months)	29.6	42.7	39.1	39.1	41
Variability in age (sigmas)	4.3	4.8	7.8	6.4	5.2
Age range (months)	24-36	33-50	26-48	20-50	32-51
Sex	Boys 62% Girls 38%	Boys 68% Girls 32%	Boys 29% Girls 71%	Boys 53% Girls 47%	Boys 56% Girls 44%
Relative I.Q. status	Middle (112-136)	High (125-134)	Low (110)	Low (107)	Middle (114)
Toys and equipment (relative status)	Middle	High	Low	Low	Middle
Play Space	Limited (roof)	Large	Limited	Limited	Large
No. of teachers connected with the group	4	5	1 or 2	2	3
Proportion of conflicts interfered with by teachers	32.6%	36.2%	26.6%	32.5%	16.5%
National background:					
N. Europe	66%	74%	47%	100%	68.7%
Jewish	34%	26%			
S. Europe			53%		31.3%
Av. education of fathers (no. of yrs.)				9.8	9.3
Av. education of mothers (no. of yrs.)				11.9	9.7
Av. no. of children in family				3.2	2.6
Av. birth order				2.6	2.3

We present below the results of analysis when the sub-populations are taken to consist of the four main nursery school groups in Table 2 (the Chicago group is omitted because the observations were incomplete).

In computing the inter-group and intra-group variance, it is customary to work simply with the numerators of the variance formulae, since they are the numbers which determine the percentage of contribution. These appear below as the total sum of squares, the sum of squares be-

tween means, and the sum of squares within groups. The first set of values below are obtained from the direct observations for the four groups.

	Group A	Group B	Group C	Bloomington
Mean	30.2	16.0	38.1	15.4
Sigma	8.5	8.0	9.1	8.2

Total sum of squares:	11,731
Sum of squares between means:	6,653
Sum of squares within groups:	5,078
Inter-group variance:	56.7%
Intra-group variance:	43.3%

In other words, more than half the total conflict variance is to be attributed to causal factors which differ from group to group.

An analysis of the variance of total conflict frequencies (direct plus indirect) gives similar results.

	Group A	Group B	Group C	Bloomington
Mean	62.1	34.3	80.7	30.8
Sigma	24.8	15.5	24.1	16.2

Total sum of squares:	57,867
Sum of squares between means:	29,126
Sum of squares within groups:	28,741
Inter-group variance:	50.3%
Intra-group variance:	49.7%

Addition of the indirect observations does not change the results significantly.

This means that sets of influences which vary from nursery-school population to nursery-school population are a much more important source of differences in conflict behavior than any of the general categories (age, sex, intelligence) discussed above, which cut across all the groups, within the age and intelligence limits of the present study. Instead of regarding this as unsatisfactory because it interferes with blanket generalizations about conflicts or other social behavior, and age, intelligence, etc., which would cover all children, this inter-group variance can be capitalized to give more concrete information about the formation of personality than is possible with any treatment in terms of uniformly acting general concepts.

The exact figures for the inter-group and intra-group variances would undoubtedly fluctuate somewhat if the study were to be repeated on groups as similar as possible to these; it seems an adequate approximation to treat each variance as half the total. If about half the variance is attributable to differences between groups, and if this were interpreted in correlational terms, a correlation of around .70 would be indicated. Treatment of these results with the ordinary standard error procedures is not appropriate. These sub-populations are not random samples, but sorted and selected samples of the total population. It seems more promising to make the assumption that these values are relatively errorless, and to go on from there, than to combine diverse groups in an attempt to reduce the probable errors of the values. If future work shows this to be a fruitful procedure, all is well; if not, no great harm

has been done. Further work on more groups would result in a filling in of the total distribution of groups. Exactly what part of the total distribution of groups is represented here, it is impossible to say.

DISCUSSION OF RESULTS

The above analysis has given a division of the total variance of conflict behavior into a half that is due to differences in behavior within the groups and a half that is due to differences in behavior between groups. The primary value of this division is that it indicates where we should look to find the causes of difference in conflicts; to explain the inter-group differences, the important variables are those that vary from sub-population to sub-population, within and outside of the observational setting. It seems likely that at least half of the intra-group variance can be explained by reference to other variables in the behavior of the specific child, such as his number of social contacts, skill in getting along with other children, etc. Which of these would be dependent and which independent variables remains to be seen.

If we could explain why the upper and lower children in each group fell toward the ends of their distributions well enough to account for half the intra-group variance, again to draw an analogy with correlational procedure, the part of the variance accounted for would be equal to that obtained with a correlation of .87. We hope to gain further information on intra-group differences from work in progress on the interrelationship of different types of behavior.

A corollary of our analysis is the consideration of each child in relation to the mean of his own group, instead of in relation to a more general average. Thus the child who engaged in the most conflicts in the Bloomington group had a conflict frequency in direct observations which was not significantly above the general average of Jersild and Markey's three groups. She was considered a general behavior problem at the school, and would show considerable "maladjustment" by almost any criterion. It seems more meaningful to consider her as an extreme case in her own distribution than as near the average of all the children in all the groups. We have no way of telling what would happen to the conflict frequency of a child if he were changed from a high-conflict group to a low one, or vice versa, and given time to become readjusted. Shifts of this kind would enable us to estimate the influence of the group of children as a group on the conflict frequency of a particular child to an extent not possible at present.

The primary concern of the present paper is with the difference between groups. The causal factors here may first be divided into two groups 1) the various factors within the nursery school: the number and conduct of the teachers, the amount of play space, the number of toys, etc., 2) influences in the history of the individual children, particularly those outside the nursery school.

It is difficult to make an accurate assessment of the influence of individual differences in the conduct of teachers on the frequency of various kinds of behavior, but what information we have indicates that this is of minor importance. In the Bloomington school there were never more than two teachers present, and occasionally only one. In the

Jersild and Markey schools, there were four teachers in the A nursery school, five in the B school, and one or two in the C school. Obviously the number of teachers is not the decisive factor in the low frequency of conflicts in the Bloomington group. A value used by Jersild and Markey in estimating the influence of teachers is the per cent of conflicts in which the teachers interfered. Our discussion above indicated that this was not a decisive factor in these groups.

Concerning play space, the Bloomington group had less space per child than is available in most university nursery schools, and less than that in the Chicago school, so that here again the causes of difference in behavior must be sought elsewhere. This is not to say that none of these factors could ever be influential, but that their collective effect for the specific groups under discussion would account for only a small part of the inter-group variance.

This leads to a consideration of the influences in the extra-nursery-school history of the individual children. If we examine his behavior in enough detail, every child is, of course, unique, as is every other object of scientific examination. We have seen that the most likely general psychological divisions (age, sex, and intelligence) do not account for any appreciable part of the variance of conflict behavior in these particular populations. But we have also found that children who seem very "individual" when compared with their associates exhibit similarity when compared with other and quite different groups, so that some generality of treatment is possible. If we can find out why different groups give different values in different kinds of behavior we will have a part of the "individuality" of the individual child explained.

What the method used in this paper does, essentially, as opposed to the more commonly used correlational procedure, is to give an estimate of the amount of variance due to whole sets of causal influences, whether or not all the important factors are explicitly recognized. We cannot even be sure that we can list all the bases of selection which operated to form the particular sets of children discussed here. What we can say is that a whole set of factors, known and unknown, suspected and unsuspected, is responsible for the observed differences between sub-populations in conflict behavior. This outlines the problem.

An adequate treatment of the influences determining these differences in behavior would include all the things that are ordinarily treated in the psychology of personality. Instead of listing these, we will merely point to the families of the children involved, and express the opinion that these differences between groups are the result primarily of the differences, cultural and non-cultural, between the different groups of families and the complex circumstances in which they live. This merely indicates the locus of the problem, rather than supplying a set of answers.[3] Linton (17) offers an interesting hypothesis concerning the relative effect of cultural and non-cultural factors in interpersonal situations. "In general it seems that the closer and more continuous the relations between individuals, the greater the influence of those non-cultural factors relative to the social and cultural ones . . .The social contacts of the child are largely of this close, highly individualized

[3] *A careful discussion of "environmental" influences on the behavior of children is given by Arrington (2).*

sort, and the qualities of the people with whom he is associated are certainly of great importance in shaping his personality. Whether their effect is greater or less than that of the formal patterns of his society's culture is a question which we cannot at present answer" (17, p. 436). In dealing with specific persons it is often difficult or even impossible to say whether a given form of behavior is cultural or non-cultural in origin since cultural influences are mediated through specific persons, particularly through the parents, and so reach the child only in intermixture with the personal idiosyncracies of some specific person. A good description of the actual process of behavior formation is given by Anderson (1, pp. 850-851). "To the wide variety of situations to which he is exposed, the child reacts with a wide variety of responses. In his early years he tries out many techniques, such as whimpering, scolding, tantrums, smiling, giving in, wheedling, etc. Some result in unfavorable action on the part of others, some elicit favorable reactions. As a result, there is a continuous selection and sorting-over of responses, with selection of some and elimination of others. . .At first this process is unconscious and involuntary; later it may be quite deliberate and voluntary." Some actions which bring a desired response from a parent may be such as to bring a child into coincidence with cultural ways of behaving, as in the case of the earliest uses of language by a child, but others, for example, temper tantrums, may be reinforced by success although they are not in any way culturally prescribed, and although they may prove to be successful social techniques with only one other individual.

We have facing us an "inverse probability" problem, similar to that we should have if a person should say to us, "Last night in a bridge game, on the tenth hand, I made a small slam. What cards did I hold?" A child with one set of factors in his background may engage in the same number of conflicts as another with a quite different history. Our approach here partially overcomes the indeterminacy of the inverse probability problem of pointing to combinations of causal factors that give consistent differences between sub-populations of children. Although we cannot assess the weight of each separate variable in the combinations, we can estimate the weight of the combinations themselves. We can obtain information that would be lost if all the populations were combined and correlations computed, and we can predict the behavior of individual children in a way not possible with correlations computed for the whole population. If the same procedure were followed with other types of behavior, and for additional groups, we should be able to speak with more confidence about the influence of specific variables, as opposed to the influence of unanalyzed combinations of variables.

Specific hypotheses about individual variables may well wait until a wider variety of groups of children have been studied. It is quite possible that various causal factors may have significantly different weight in different populations; a particular form of behavior may occur with greater frequency with increase in intellectual level in one group, and show no such relation in another. That is, a causal factor which may have a strong influence in one group may show a zero weighting in another. This simply means that we will have to formulate increasingly complex theoretical structures to obtain predictability in this particular field.

The analysis of variance procedure used in the present paper represents one way in which this can be achieved in a systematic manner.

SUMMARY

The primary concern of this paper is the development of a procedure for dealing with differences in behavior in groups of preschool children from different settings. The results of our observations of the frequency of conflict behavior in two W.P.A. nursery school groups are combined with those of Jersild and Markey for three other nursery schools. An analysis of the variance of frequency of conflicts is made, which indicates that approximately half the total variance is due to inter-group factors and the other half to intra-group factors. Age, sex, intelligence, socio-economic group, and factors in the nursery school set-up failed to contribute significantly to the total variance in these groups. A need for more concrete descriptions of differences in social and family backgrounds than are now available is indicated as necessary for explanation of the inter-group behavior differences. Some of the implications of the analysis of variance technique as applied to individual differences in personality characteristics of preschool children are discussed.

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A TABLE OF THE DOUBLE INTEGRAL OF THE GAUSSIAN PROBABILITY FUNCTION[1]

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In the course of studies[2] on the eruption of the permanent teeth in children, it was found that a mathematical description of the age distribution of eruption of the separate morphological types of teeth could be obtained through the use of the normal probability (Gaussian) frequency function. In these investigations it was shown that the percentages of children at successive chronological ages who had a particular permanent tooth erupted into the mouth followed an S-shaped curve which could be fitted satisfactorily by the integral of the normal probability function. This finding leads to the observation that the area under the S-shaped curve (the double integral of the probability function) to any chronological age represents the total number of years of exposure of the tooth in the mouth per 100 children. The values of this area, which provide a measure of accumulated post-eruptive tooth age, have been found of considerable utility in studies on dental caries. The determination of post-eruptive tooth age values requires estimates of the double integral of the normal probability function ($\int_{-\infty}^{X} \int_{-\infty}^{X} e^{-X^2} dX$).

So far as the authors are aware, no tabled values of this double integral are available. Since it seems likely that these values may be useful in connection with other studies, it has seemed worth while to publish in full Table 1, which was prepared in connection with the studies on dental caries.

The arithmetic values of the double integral were derived by a finite difference method from values of the single integral given in Pearson's Tables.[3] The actual computations were carried out as follows: Values of the single integral for <u>even</u> one-one-hundredth values of the argument, X, were multiplied by .02 and added successively from X = -4.48 to X = + 4.48. This procedure gave values of the double integral at successive odd values of the argument from X = -4.49 to X = + 4.49. In a similar way values of the double integral were obtained for even values of the argument from X = -4.50 to X = + 4.50. In the calculations, the seven decimal place figures given in Pearson's tables were used, eight decimal places were carried after multiplication by .02, and the final double integral values obtained by successive addition were rounded to seven decimal places. The table has been carefully checked and is believed correct to six decimal places.

In this procedure the value of the double integral between $-\infty$ and X = -4.50 has been neglected. However, this does not decrease appreciably the values in the table since it is readily seen that the double integral converges very rapidly.[4]

[1] *From the Division of Public Health Methods, National Institute of Health, Bethesda, Maryland.*

[2] *See, Growth, Vol. I, p. 385 (1937), also Vol. II, p. 149 (1938).*

[3] *Pearson, K. Tables for Statisticians and Biometricians, Part I, Cambridge University Press. London (1924).*

[4] *The proof for this fact is similar to that used by Wintner in another connection. See, Wintner, Aurel, On the Asymptotic Formulae of Riemann and of LaPlace, Proc. Nat. Acad. of Sc. 20:57-62, (1934).*

In fact $\int_{-\infty}^{-|\epsilon|} e^{-X^2}\,dX < \int_{-\infty}^{-|\epsilon|} e^{-|X|}\,dX = \int_{-\infty}^{-|\epsilon|} e^{X}\,dX = e^{X}\Big|_{-\infty}^{-|\epsilon|} = e^{-|\epsilon|}$

$$\therefore \int_{-\infty}^{-|\epsilon|}\int_{-\infty}^{-|\epsilon|} e^{-X^2}\,dX < \int_{-\infty}^{-|\epsilon|} e^{X}\,dX = e^{-|\epsilon|}$$

which can be made as small as desired.

It should be noted that it would be sufficient to present the values of the double integral only for negative values of the argument. The values of the double integral for positive X may be obtained by adding the arithmetic value of X to the value of the double integral at -X. This fact follows as a consequent of the symmetry of the curve $F(X) = \int e^{-X^2}\,dX$ with respect to (0, F (0)). In fact, from the accompanying figure it is seen that

$$\frac{1}{\sqrt{\pi}}\int_{-Xo}^{Xo}\int e^{-X^2}\,dX = Xo$$

For, from the symmetry of F (X)

$$A = A'$$

Also $B + A' = Xo$

Hence $\frac{1}{\sqrt{\pi}}\int_{-Xo}^{Xo}\int e^{-X^2}\,dX = B + A = Xo.$

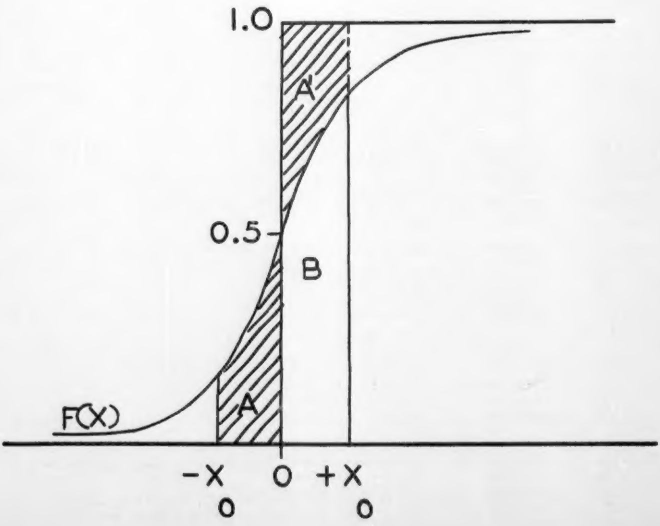

TABLE 1

X	Double Integral	X	Double Integral	X	Double Integral
- 4.50	.0000000	- 4.00	.0000065	- 3.50	.0000578
- 4.49	.0000000	- 3.99	.0000068	- 3.49	.0000601
- 4.48	.0000001	- 3.98	.0000071	- 3.48	.0000626
- 4.47	.0000001	- 3.97	.0000075	- 3.47	.0000652
- 4.46	.0000002	- 3.96	.0000079	- 3.46	.0000678
- 4.45	.0000002	- 3.95	.0000082	- 3.45	.0000706
- 4.44	.0000002	- 3.94	.0000086	- 3.44	.0000734
- 4.43	.0000003	- 3.93	.0000090	- 3.43	.0000764
- 4.42	.0000003	- 3.92	.0000095	- 3.42	.0000794
- 4.41	.0000004	- 3.91	.0000099	- 3.41	.0000826
- 4.40	.0000004	- 3.90	.0000104	- 3.40	.0000859
- 4.39	.0000005	- 3.89	.0000109	- 3.39	.0000894
- 4.38	.0000006	- 3.88	.0000114	- 3.38	.0000929
- 4.37	.0000006	- 3.87	.0000119	- 3.37	.0000966
- 4.36	.0000007	- 3.86	.0000125	- 3.36	.0001005
- 4.35	.0000008	- 3.85	.0000131	- 3.35	.0001004
- 4.34	.0000008	- 3.84	.0000137	- 3.34	.0001085
- 4.33	.0000009	- 3.83	.0000143	- 3.33	.0001128
- 4.32	.0000010	- 3.82	.0000150	- 3.32	.0001172
- 4.31	.0000011	- 3.81	.0000156	- 3.31	.0001218
- 4.30	.0000011	- 3.80	.0000163	- 3.30	.0001265
- 4.29	.0000012	- 3.79	.0000171	- 3.29	.0001315
- 4.28	.0000013	- 3.78	.0000178	- 3.28	.0001366
- 4.27	.0000014	- 3.77	.0000186	- 3.27	.0001419
- 4.26	.0000015	- 3.76	.0000195	- 3.26	.0001473
- 4.25	.0000016	- 3.75	.0000203	- 3.25	.0001530
- 4.24	.0000017	- 3.74	.0000212	- 3.24	.0001589
- 4.23	.0000018	- 3.73	.0000222	- 3.23	.0001649
- 4.22	.0000020	- 3.72	.0000232	- 3.22	.0001712
- 4.21	.0000021	- 3.71	.0000242	- 3.21	.0001778
- 4.20	.0000022	- 3.70	.0000252	- 3.20	.0001845
- 4.19	.0000023	- 3.69	.0000263	- 3.19	.0001915
- 4.18	.0000025	- 3.68	.0000275	- 3.18	.0001988
- 4.17	.0000026	- 3.67	.0000287	- 3.17	.0002062
- 4.16	.0000028	- 3.66	.0000299	- 3.16	.0002140
- 4.15	.0000029	- 3.65	.0000312	- 3.15	.0002220
- 4.14	.0000031	- 3.64	.0000325	- 3.14	.0002303
- 4.13	.0000033	- 3.63	.0000339	- 3.13	.0002389
- 4.12	.0000035	- 3.62	.0000354	- 3.12	.0002478
- 4.11	.0000037	- 3.61	.0000368	- 3.11	.0002570
- 4.10	.0000039	- 3.60	.0000384	- 3.10	.0002665
- 4.09	.0000041	- 3.59	.0000400	- 3.09	.0002763
- 4.08	.0000043	- 3.58	.0000417	- 3.08	.0002865
- 4.07	.0000045	- 3.57	.0000435	- 3.07	.0002970
- 4.06	.0000048	- 3.56	.0000453	- 3.06	.0003079
- 4.05	.0000050	- 3.55	.0000472	- 3.05	.0003192
- 4.04	.0000053	- 3.54	.0000491	- 3.04	.0003308
- 4.03	.0000056	- 3.53	.0000512	- 3.03	.0003428
- 4.02	.0000059	- 3.52	.0000533	- 3.02	.0003553
- 4.01	.0000061	- 3.51	.0000555	- 3.01	.0003681

TABLE 1 (Continued)

X	Double Integral	X	Double Integral	X	Double Integral
- 3.00	.0003814	- 2.50	.0020032	- 2.00	.0084891
- 2.99	.0003951	- 2.49	.0020661	- 1.99	.0087193
- 2.98	.0004093	- 2.48	.0021309	- 1.98	.0089550
- 2.97	.0004239	- 2.47	.0021975	- 1.97	.0091963
- 2.96	.0004391	- 2.46	.0022660	- 1.96	.0094434
- 2.95	.0004547	- 2.45	.0023365	- 1.95	.0096963
- 2.94	.0004709	- 2.44	.0024089	- 1.94	.0099552
- 2.93	.0004875	- 2.43	.0024833	- 1.93	.0102201
- 2.92	.0005048	- 2.42	.0025599	- 1.92	.0104912
- 2.91	.0005225	- 2.41	.0026385	- 1.91	.0107687
- 2.90	.0005409	- 2.40	.0027194	- 1.90	.0110526
- 2.89	.0005598	- 2.39	.0028025	- 1.89	.0113430
- 2.88	.0005794	- 2.38	.0028879	- 1.88	.0116401
- 2.87	.0005996	- 2.37	.0029756	- 1.87	.0119441
- 2.86	.0006205	- 2.36	.0030658	- 1.86	.0122550
- 2.85	.0006420	- 2.35	.0031583	- 1.85	.0125730
- 2.84	.0006642	- 2.34	.0032535	- 1.84	.0128981
- 2.83	.0006871	- 2.33	.0033512	- 1.83	.0132306
- 2.82	.0007107	- 2.32	.0034516	- 1.82	.0135706
- 2.81	.0007351	- 2.31	.0035546	- 1.81	.0139182
- 2.80	.0007603	- 2.30	.0036604	- 1.80	.0142736
- 2.79	.0007862	- 2.29	.0037691	- 1.79	.0146368
- 2.78	.0008130	- 2.28	.0038807	- 1.78	.0150081
- 2.77	.0008406	- 2.27	.0039952	- 1.77	.0153876
- 2.76	.0008690	- 2.26	.0041127	- 1.76	.0157754
- 2.75	.0008984	- 2.25	.0042334	- 1.75	.0161717
- 2.74	.0009286	- 2.24	.0043572	- 1.74	.0165766
- 2.73	.0009598	- 2.23	.0044843	- 1.73	.0169903
- 2.72	.0009920	- 2.22	.0046147	- 1.72	.0174129
- 2.71	.0010251	- 2.21	.0047485	- 1.71	.0178446
- 2.70	.0010593	- 2.20	.0048858	- 1.70	.0182855
- 2.69	.0010944	- 2.19	.0050265	- 1.69	.0187359
- 2.68	.0011307	- 2.18	.0051710	- 1.68	.0191958
- 2.67	.0011681	- 2.17	.0053191	- 1.67	.0196655
- 2.66	.0012066	- 2.16	.0054711	- 1.66	.0201450
- 2.65	.0012462	- 2.15	.0056268	- 1.65	.0206346
- 2.64	.0012871	- 2.14	.0057866	- 1.64	.0211345
- 2.63	.0013291	- 2.13	.0059504	- 1.63	.0216447
- 2.62	.0013724	- 2.12	.0061183	- 1.62	.0221655
- 2.61	.0014170	- 2.11	.0062904	- 1.61	.0221655
- 2.60	.0014630	- 2.10	.0064669	- 1.60	.0232395
- 2.59	.0015102	- 2.09	.0066477	- 1.59	.0237930
- 2.58	.0015590	- 2.08	.0068331	- 1.58	.0243578
- 2.57	.0016090	- 2.07	.0070230	- 1.57	.0249340
- 2.56	.0016607	- 2.06	.0072176	- 1.56	.0255220
- 2.55	.0017137	- 2.05	.0074170	- 1.55	.0261216
- 2.54	.0017684	- 2.04	.0076213	- 1.54	.0267334
- 2.53	.0018246	- 2.03	.0078305	- 1.53	.0273572
- 2.52	.0018824	- 2.02	.0080448	- 1.52	.0279935
- 2.51	.0019419	- 2.01	.0082643	- 1.51	.0286423

TABLE 1 (Continued)

X	Double Integral	X	Double Integral	X	Double Integral
- 1.50	.0293040	- 1.00	.0833108	- .50	.1977900
- 1.49	.0299785	- .99	.0849094	- .49	.2008930
- 1.48	.0306662	- .98	.0865325	- .48	.2040313
- 1.47	.0313672	- .97	.0881803	- .47	.2072053
- 1.46	.0320818	- .96	.0898530	- .46	.2104149
- 1.45	.0328101	- .95	.0915508	- .45	.2136604
- 1.44	.0335524	- .94	.0932741	- .44	.2169420
- 1.43	.0343088	- .93	.0950230	- .43	.2202598
- 1.42	.0350796	- .92	.0967978	- .42	.2236140
- 1.41	.0358649	- .91	.0985987	- .41	.2270046
- 1.40	.0366650	- .90	.1004260	- .40	.2304320
- 1.39	.0374800	- .89	.1022799	- .39	.2338962
- 1.38	.0383103	- .88	.1041607	- .38	.2373974
- 1.37	.0391559	- .87	.1060685	- .37	.2409357
- 1.36	.0400171	- .86	.1080037	- .36	.2445112
- 1.35	.0408942	- .85	.1099664	- .35	.2481241
- 1.34	.0417873	- .84	.1119569	- .34	.2517746
- 1.33	.0426966	- .83	.1139755	- .33	.2554627
- 1.32	.0436225	- .82	.1160223	- .32	.2591886
- 1.31	.0445650	- .81	.1180977	- .31	.2629524
- 1.30	.0455244	- .80	.1202017	- .30	.2667542
- 1.29	.0465010	- .79	.1223348	- .29	.2705942
- 1.28	.0474949	- .78	.1244970	- .28	.2744724
- 1.27	.0485064	- .77	.1266887	- .27	.2783889
- 1.26	.0495358	- .76	.1289100	- .26	.2823440
- 1.25	.0505831	- .75	.1311612	- .25	.2863376
- 1.24	.0516488	- .74	.1334426	- .24	.2903698
- 1.23	.0527329	- .73	.1357542	- .23	.2944409
- 1.22	.0538358	- .72	.1380965	- .22	.2985508
- 1.21	.0549575	- .71	.1404695	- .21	.3026996
- 1.20	.0560985	- .70	.1428735	- .20	.3068874
- 1.19	.0572589	- .69	.1453087	- .19	.3111144
- 1.18	.0584390	- .68	.1477754	- .18	.3153806
- 1.17	.0596389	- .67	.1502738	- .17	.3196859
- 1.16	.0608590	- .66	.1528040	- .16	.3240306
- 1.15	.0620994	- .65	.1553663	- .15	.3284147
- 1.14	.0633605	- .64	.1579609	- .14	.3328383
- 1.13	.0646423	- .63	.1605881	- .13	.3373013
- 1.12	.0659452	- .62	.1632479	- .12	.3418039
- 1.11	.0672694	- .61	.1659406	- .11	.3463462
- 1.10	.0686152	- .60	.1686665	- .10	.3509280
- 1.09	.0699828	- .59	.1714257	- .09	.3555496
- 1.08	.0713723	- .58	.1742184	- .08	.3602109
- 1.07	.0727842	- .57	.1770448	- .07	.3649120
- 1.06	.0742185	- .56	.1799052	- .06	.3696528
- 1.05	.0756756	- .55	.1827996	- .05	.3744335
- 1.04	.0771557	- .54	.1857284	- .04	.3792541
- 1.03	.0786590	- .53	.1886916	- .03	.3841146
- 1.02	.0801858	- .52	.1916895	- .02	.3890147
- 1.01	.0817363	- .51	.1947222	- .01	.3939549

TABLE 1 (Continued)

X	Double Integral	X	Double Integral	X	Double Integral
.00	.3989349	+ .51	.7047222	+1.01	1.0917363
+ .01	.4039549	+ .52	.7116895	+1.02	1.1001858
+ .02	.4090147	+ .53	.7186916	+1.03	1.1086590
+ .03	.4141145	+ .54	.7257284	+1.04	1.1171557
+ .04	.4192541	+ .55	.7327996	+1.05	1.1256756
+ .05	.4244335				
+ .06	.4296528	+ .56	.7399052	+1.06	1.1342185
+ .07	.4349120	+ .57	.7470448	+1.07	1.1427842
+ .08	.4402109	+ .58	.7542184	+1.08	1.1513723
+ .09	.4455496	+ .59	.7614257	+1.09	1.1599828
+ .10	.4509280	+ .60	.7686665	+1.10	1.1686152
+ .11	.4563462	+ .61	.7759406	+1.11	1.1772694
+ .12	.4618039	+ .62	.7832479	+1.12	1.1859452
+ .13	.4673013	+ .63	.7905881	+1.13	1.1946423
+ .14	.4728383	+ .64	.7979609	+1.14	1.2033605
+ .15	.4784147	+ .65	.8053663	+1.15	1.2120994
+ .16	.4840306	+ .66	.8128040	+1.16	1.2208590
+ .17	.4896859	+ .67	.8202738	+1.17	1.2296389
+ .18	.4953805	+ .68	.8277764	+1.18	1.2384390
+ .19	.5011144	+ .69	.8353087	+1.19	1.2472589
+ .20	.5068874	+ .70	.8428735	+1.20	1.2560985
+ .21	.5126996	+ .71	.8504695	+1.21	1.2649575
+ .22	.5185508	+ .72	.8580965	+1.22	1.2738358
+ .23	.5244409	+ .73	.8657542	+1.23	1.2827329
+ .24	.5303698	+ .74	.8734426	+1.24	1.2916488
+ .25	.5363376	+ .75	.8811612	+1.25	1.3005831
+ .26	.5423440	+ .76	.8889100	+1.26	1.3095358
+ .27	.5483889	+ .77	.8966887	+1.27	1.3185064
+ .28	.5544724	+ .78	.9044970	+1.28	1.3274949
+ .29	.5605942	+ .79	.9123348	+1.29	1.3365010
+ .30	.5667542	+ .80	.9202017	+1.30	1.3455244
+ .31	.5729524	+ .81	.9280977	+1.31	1.3545650
+ .32	.5791886	+ .82	.9360223	+1.32	1.3636225
+ .33	.5854627	+ .83	.9439755	+1.33	1.3726966
+ .34	.5917746	+ .84	.9519569	+1.34	1.3817873
+ .35	.5981241	+ .85	.9599664	+1.35	1.3908942
+ .36	.6045112	+ .86	.9680037	+1.36	1.4000171
+ .37	.6109357	+ .87	.9760685	+1.37	1.4091559
+ .38	.6173974	+ .88	.9841607	+1.38	1.4183103
+ .39	.6238962	+ .89	.9922799	+1.39	1.4274800
+ .40	.6304320	+ .90	1.0004260	+1.40	1.4366650
+ .41	.6370046	+ .91	1.0085987	+1.41	1.4458649
+ .42	.6436140	+ .92	1.0167978	+1.42	1.4550796
+ .43	.6502598	+ .93	1.0250230	+1.43	1.4643088
+ .44	.6569420	+ .94	1.0332741	+1.44	1.4735524
+ .45	.6636604	+ .95	1.0415508	+1.45	1.4828101
+ .46	.6704149	+ .96	1.0498530	+1.46	1.4920818
+ .47	.6772053	+ .97	1.0581803	+1.47	1.5013672
+ .48	.6840313	+ .98	1.0665325	+1.48	1.5106662
+ .49	.6908930	+ .99	1.0749094	+1.49	1.5199785
+ .50	.6977900	+1.00	1.0833108	+1.50	1.5293040

TABLE 1 (Continued)

X	Double Integral	X	Double Integral	X	Double Integral
+1.51	1.5386423	+2.01	2.0182643	+2.51	2.5119419
+1.52	1.5479935	+2.02	2.0280448	+2.52	2.5218824
+1.53	1.5573572	+2.03	2.0378305	+2.53	2.5318246
+1.54	1.5667334	+2.04	2.0476213	+2.54	2.5417684
+1.55	1.5761216	+2.05	2.0574170	+2.55	2.5517137
+1.56	1.5855220	+2.06	2.0672176	+2.56	2.5616607
+1.57	1.5949340	+2.07	2.0770230	+2.57	2.5716090
+1.58	1.6043578	+2.08	2.0868331	+2.58	2.5815590
+1.59	1.6137930	+2.09	2.0966477	+2.59	2.5915102
+1.60	1.6232395	+2.10	2.1064669	+2.60	2.6014630
+1.61	1.6326970	+2.11	2.1162904	+2.61	2.6114170
+1.62	1.6421655	+2.12	2.1261183	+2.62	2.6213724
+1.63	1.6516447	+2.13	2.1359504	+2.63	2.6313291
+1.64	1.6611345	+2.14	2.1457866	+2.64	2.6412871
+1.65	1.6706346	+2.15	2.1556268	+2.65	2.6512462
+1.66	1.6801450	+2.16	2.1654711	+2.66	2.6612066
+1.67	1.6896655	+2.17	2.1753191	+2.67	2.6711681
+1.68	1.6991958	+2.18	2.1851710	+2.68	2.6811307
+1.69	1.7087359	+2.19	2.1950265	+2.69	2.6910944
+1.70	1.7182855	+2.20	2.2048858	+2.70	2.7010593
+1.71	1.7278446	+2.21	2.2147485	+2.71	2.7110251
+1.72	1.7374129	+2.22	2.2246147	+2.72	2.7209920
+1.73	1.7469903	+2.23	2.2344843	+2.73	2.7309598
+1.74	1.7565766	+2.24	2.2443572	+2.74	2.7409286
+1.75	1.7661717	+2.25	2.2542334	+2.75	2.7508984
+1.76	1.7757754	+2.26	2.2641127	+2.76	2.7608690
+1.77	1.7853876	+2.27	2.2739952	+2.77	2.7708406
+1.78	1.7950081	+2.28	2.2838807	+2.78	2.7808130
+1.79	1.8046368	+2.29	2.2937691	+2.79	2.7907862
+1.80	1.8142736	+2.30	2.3036604	+2.80	2.8007603
+1.81	1.8239182	+2.31	2.3135546	+2.81	2.8107351
+1.82	1.8335706	+2.32	2.3234516	+2.82	2.8207107
+1.83	1.8432306	+2.33	2.3333512	+2.83	2.8306871
+1.84	1.8528981	+2.34	2.3432535	+2.84	2.8406642
+1.85	1.8625730	+2.35	2.3531583	+2.85	2.8506420
+1.86	1.8722550	+2.36	2.3630658	+2.86	2.8606205
+1.87	1.8819441	+2.37	2.3729756	+2.87	2.8705996
+1.88	1.8916401	+2.38	2.3828879	+2.88	2.8805794
+1.89	1.9013430	+2.39	2.3928025	+2.89	2.8905598
+1.90	1.9110526	+2.40	2.4027194	+2.90	2.9005409
+1.91	1.9207687	+2.41	2.4126385	+2.91	2.9105225
+1.92	1.9304912	+2.42	2.4225599	+2.92	2.9205048
+1.93	1.9402201	+2.43	2.4324833	+2.93	2.9304875
+1.94	1.9499552	+2.44	2.4424089	+2.94	2.9404709
+1.95	1.9596963	+2.45	2.4523365	+2.95	2.9504547
+1.96	1.9694434	+2.46	2.4622660	+2.96	2.9604391
+1.97	1.9791963	+2.47	2.4721975	+2.97	2.9704239
+1.98	1.9889550	+2.48	2.4821309	+2.98	2.9804093
+1.99	1.9987193	+2.49	2.4920661	+2.99	2.9903951
+2.00	2.0084891	+2.50	2.5020032	+3.00	3.0003814

TABLE 1 (Concluded)

X	Double Integral	X	Double Integral	X	Double Integral
+ 3.01	3.0103681	+ 3.51	3.5100555	+ 4.01	4.0100061
+ 3.02	3.0203553	+ 3.52	3.5200533	+ 4.02	4.0200059
+ 3.03	3.0303428	+ 3.53	3.5300512	+ 4.03	4.0300056
+ 3.04	3.0403308	+ 3.54	3.5400491	+ 4.04	4.0400053
+ 3.05	3.0503192	+ 3.55	3.5500472	+ 4.05	4.0500050
+ 3.06	3.0603079	+ 3.56	3.5600453	+ 4.06	4.0600048
+ 3.07	3.0702970	+ 3.57	3.5700435	+ 4.07	4.0700045
+ 3.08	3.0802865	+ 3.58	3.5800417	+ 4.08	4.0800043
+ 3.09	3.0902763	+ 3.59	3.5900400	+ 4.09	4.0900041
+ 3.10	3.1002665	+ 3.60	3.6000384	+ 4.10	4.1000039
+ 3.11	3.1102570	+ 3.61	3.6100368	+ 4.11	4.1100037
+ 3.12	3.1202478	+ 3.62	3.6200354	+ 4.12	4.1200035
+ 3.13	3.1302389	+ 3.63	3.6300339	+ 4.13	4.1300033
+ 3.14	3.1402303	+ 3.64	3.6400325	+ 4.14	4.1400031
+ 3.15	3.1502220	+ 3.65	3.6500312	+ 4.15	4.1500029
+ 3.16	3.1602140	+ 3.66	3.6600299	+ 4.16	4.1600028
+ 3.17	3.1702062	+ 3.67	3.6700287	+ 4.17	4.1700026
+ 3.18	3.1801988	+ 3.68	3.6800275	+ 4.18	4.1800025
+ 3.19	3.1901915	+ 3.69	3.6900263	+ 4.19	4.1900023
+ 3.20	3.2001845	+ 3.70	3.7000252	+ 4.20	4.2000022
+ 3.21	3.2101778	+ 3.71	3.7100242	+ 4.21	4.2100021
+ 3.22	3.2201712	+ 3.72	3.7200232	+ 4.22	4.2200020
+ 3.23	3.2301649	+ 3.73	3.7300222	+ 4.23	4.2300018
+ 3.24	3.2401589	+ 3.74	3.7400212	+ 4.24	4.2400017
+ 3.25	3.2501530	+ 3.75	3.7500203	+ 4.25	4.2500016
+ 3.26	3.2601473	+ 3.76	3.7600195	+ 4.26	4.2600015
+ 3.27	3.2701419	+ 3.77	3.7700186	+ 4.27	4.2700014
+ 3.28	3.2801366	+ 3.78	3.7800178	+ 4.28	4.2800013
+ 3.29	3.2901315	+ 3.79	3.7900171	+ 4.29	4.2900012
+ 3.30	3.3001265	+ 3.80	3.8000163	+ 4.30	4.3000011
+ 3.31	3.3101218	+ 3.81	3.8100156	+ 4.31	4.3100011
+ 3.32	3.3201172	+ 3.82	3.8200150	+ 4.32	4.3200010
+ 3.33	3.3301128	+ 3.83	3.8300143	+ 4.33	4.3300009
+ 3.34	3.3401085	+ 3.84	3.8400137	+ 4.34	4.3400008
+ 3.35	3.3501044	+ 3.85	3.8500131	+ 4.35	4.3500008
+ 3.36	3.3601005	+ 3.86	3.8600125	+ 4.36	4.3600007
+ 3.37	3.3700966	+ 3.87	3.8700119	+ 4.37	4.3700006
+ 3.38	3.3800929	+ 3.88	3.8800114	+ 4.38	4.3800006
+ 3.39	3.3900894	+ 3.89	3.8900109	+ 4.39	4.3900005
+ 3.40	3.4000859	+ 3.90	3.9000104	+ 4.40	4.4000004
+ 3.41	3.4100826	+ 3.91	3.9100099	+ 4.41	4.4100004
+ 3.42	3.4200794	+ 3.92	3.9200095	+ 4.42	4.4200003
+ 3.43	3.4300764	+ 3.93	3.9300090	+ 4.43	4.4300003
+ 3.44	3.4400734	+ 3.94	3.9400086	+ 4.44	4.4400002
+ 3.45	3.4500706	+ 3.95	3.9500082	+ 4.45	4.4500002
+ 3.46	3.4600678	+ 3.96	3.9600079	+ 4.46	4.4600002
+ 3.47	3.4700652	+ 3.97	3.9700075	+ 4.47	4.4700001
+ 3.48	3.4800626	+ 3.98	3.9800071	+ 4.48	4.4800001
+ 3.49	3.4900601	+ 3.99	3.9900068	+ 4.49	4.4900000
+ 3.50	3.5000578	+ 4.00	4.0000065	+ 4.50	4.5000000

A NEW TAPPING TEST

BLAKE CRIDER[1]

The psychologist has an occasional need for a tapping test which is simple, compact, inexpensive, and at the same time is fairly reliable. It is believed we have such a test.

A Veeder counter (Stoelting No. 22403) was mounted in a heavy metal base although it can just as well be clamped to a heavy table. The handle of the counter projected upward on top of which was soldered a penny. A slight pressure on the projecting handle registers a number on the dial which is turned toward the examiner.

The examiner demonstrates the procedure for taking the test in this manner: "Take your first two fingers and extend them straight out, like this. Keep your other two fingers folded back under your thumb. When I say 'go' start tapping as fast as you can and keep on tapping until I say 'stop'!" A few taps were then made rapidly on the counter in order to demonstrate further the hand position and the procedure for tapping.

The subject was permitted to tap three seconds with the generally preferred hand, and three seconds with the other hand. This not only gave a preliminary practice with each hand but also permitted the examiner to correct any misunderstanding on the part of the subject. In these preliminary trials it was also pointed out to the subject that he was not to rest his arm on the table but was to let it swing free from the elbow.

The actual testing consisted of tapping with the preferred hand first for six seconds, the preferred hand being considered the writing or throwing hand. The score was taken from the counter and another six seconds interval followed with the other hand. This gave an interval of rest of approximately five seconds between each tapping series. This sequence was repeated until each hand tapped three, six second intervals, giving a total of 18 seconds tapping time with each hand. A split-second stop watch was used to record the time.

Preferential handedness scores were obtained by dividing the total score obtained in three series of six seconds each on one hand by the total score from three series made with the other hand, the left hand scores being used as the divisor. Each quotient was multiplied by 100. This method gave a series of scores ranging from 55 to 197. A score of 55 represents the most extreme case of left hand facility on the tapping device while a score of 179 represents the most extreme case of right hand facility.

The reliability of the tapping test was determined by correlating the scores on the first series of three tests with the second series, the first with the third, and the second with the third. This gave three correlations of .64, .65, and .67. Since the total test is three times as long as any one series the Spearman-Brown formula was applied with coefficient of reliability of .84.

The mean tapping scores on 707 subjects are recorded in the following table.

[1]*From Cleveland, Ohio*

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CRIDER: NEW TAPPING TEST

MEAN TAPPING SCORES

Age	Mean	S.D.	P.E.m	N
5	114.02	21.5	1.69	74
6	114.63	15.0	1.01	101
7	116.20	16.0	1.04	107
8	113.57	12.0	.84	92
9	117.40	14.5	.88	99
10	119.30	18.5	1.27	100
11	120.32	17.5	1.02	134